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OCTOBER 2008

HARNESSING WISCONSIN'S ENERGY RESOURCES:

AN INITIAL INVESTIGATION INTO GREAT LAKES WIND DEVELOPMENT

DOCKET 5-EI-144

Executive Summary

Challenges and Opportunities Related to the Development of Wisconsin's Off-Shore Wind Resources

PSCW Docket 5-EI-144

Introduction

Wisconsin is a net importer of energy and has few native energy resources, with the exception of renewable sources such as wind, hydroelectric, solar, and biofuels. Exploring native and renewable energy sources is timely given the heightened concerns about global warming, the availability of fuel supplies, and price volatility. Furthermore, reducing Wisconsin's reliance on fossil-fuel generation and moving towards a more diverse and renewable energy portfolio will help to achieve the net environmental benefits envisioned by the Governor's Task Force on Global Warming, including reduced carbon emissions.

The use of renewable energy in Wisconsin has grown in recent years, in large part due to the establishment of a Renewable Portfolio Standard (RPS) in Wisconsin. This standard requires that ten percent of the state's electricity be produced from renewable sources by 2015. Moreover, within the last year, both Governor Jim Doyle and the Task Force have recommended expanding the RPS to 25 percent by the year 2025, with ten percent of total retail electric sales coming from renewable resources within the state. Due to its availability, wind generation is expected to become a large component of Wisconsin's renewable energy portfolio.

Meeting the state's energy needs by generating electricity from wind offers significant environmental benefits over the use of fossil fuels. These include reduced dependence on non-native energy sources, reduced emissions of air pollutants and greenhouse gases, reductions in the generation of solid wastes, and little or no water consumption. Despite these benefits, there are concerns about using terrestrial wind resources for power, including its reliability, its relative costs, its effects on wildlife, and its impacts on existing land uses.

While some of these concerns remain, harnessing Wisconsin's off-shore wind resources offers several potential advantages over terrestrial wind projects. First, off-shore wind projects in the Great Lakes have the potential to produce power on a larger scale, and thus more economically, than terrestrial wind projects due to the presence of more robust and consistent off-shore winds. Second, off-shore projects can potentially take advantage of larger turbines than could be used on land, because it may be easier to transport the turbine components to the project site. Finally, off-shore projects may produce fewer concerns about interfering with existing land uses. Taken as a whole, these advantages have the potential to offset the challenges, risks, and higher initial costs that might be expected with developing and operating an off-shore wind project.

In recognition of these potential benefits and the need to identify potential concerns, the Task Force recommended that the Public Service Commission of Wisconsin (PSCW) and other state agencies complete a study of the feasibility of generating electricity from off-shore wind resources in the Great Lakes by December 31, 2008. In April 2008, the PSCW opened docket 5-

EI-144 and created an external Study Group to assist with examining the technical feasibility, economic potential, environmental impacts, and legal requirements associated with developing wind energy on Lake Michigan and Lake Superior. The Study Group established four work groups to look more closely at specific issues related to engineering and economics, the human environment, legal issues, and community involvement.

The Study Group found that while off-shore wind projects in the Great Lakes are technologically feasible, there are significant technical, economic, environmental, and legal issues to resolve. This report summarizes the Study Group's preliminary investigation, and includes the key findings and challenges identified by each of the work groups. Where appropriate, the Study Group identified options for addressing the most significant barriers to the development of off-shore wind should the State of Wisconsin decide to pursue this alternative energy source.

It should be noted that the Study Group was not asked to determine whether the development of off-shore wind is in the best interests of the State of Wisconsin or its citizens. As a result, nothing in this report should be construed as a recommendation for or against the development of off-shore wind projects in the Great Lakes. Instead, the report is intended to identify the key issues and to assist policy makers in evaluating the available alternatives to meeting the state's energy needs.

Engineering and Economic Issues

The Study Group assessed a variety of technical and economic issues associated with off-shore wind projects. It concluded that while the development of off-shore wind is feasible in the near-shore areas of the Great Lakes with present day technology, there are significant technological challenges with the development of wind projects in deeper water locations where the best project sites may be located, based on wind resources and other considerations. The issues and challenges identified by the Study Group were grouped into five categories: the characterization of Great Lakes wind resources; issues related to the design, installation, and decommissioning of off-shore wind projects; evaluation of transmission infrastructure; the comparative costs of off-shore wind; and project financing and incentives.

Characterization of Great Lakes Wind Resources

Any off-shore wind project in the Great lakes will need to be large to take advantage of economies of scale. Obviously, larger projects will affect larger expanses of open water. Further, European experience with off-shore wind projects has demonstrated that such projects typically require more area than comparable terrestrial wind projects, due to the wind disturbance caused by multiple rows of turbines. For example, the proposed Cape Wind project near Cape Cod, Massachusetts, with a proposed capacity of 1,800 megawatts (MW), would require 100 square miles, which is a density of about 18 MW per square mile. The same density could be expected for a similarly sized project on Lake Michigan. Although large, 100 square miles represents less than 0.5 percent of the total surface area of Lake Michigan.

At this time, it is not known whether an area of that size with suitable wind resources exists in Wisconsin's portion of the Great Lakes. One of the difficulties encountered by the Study Group was the lack of consistent, measured wind speed data for the Great Lakes. While preliminary studies suggest that Wisconsin's off-shore wind resources would be more robust for energy generation than its terrestrial wind resources, a lack of data makes the identification of the best potential sites for an off-shore project difficult. For example, it is not known whether the best wind resources would occur over deeper water, where construction of turbine foundations would be more challenging.

The Study Group believes that more comprehensive off-shore wind data is needed before proceeding with an off-shore wind project on the Great Lakes. Specifically, it would be beneficial to collect at least three years of off-shore wind data at turbine height and at the locations where projects would most likely be located. These data could be used to develop a wind potentials map of Wisconsin's off-shore wind resources that would be useful in evaluating various project locations. Additionally, this map could be also used to identify areas with good wind resources that should be eliminated at project locations due to conflicts with recreational or commercial uses, the presence of legally protected areas, or concerns about the effects of such a project on natural resources such as wildlife and fisheries.

Design, Installation, and Decommissioning of Off-Shore Wind Turbines

The Study Group investigated the design and components used in existing, commercial-scale wind projects located off-shore in Europe to identify possible engineering or technical challenges related to the construction of an off-shore wind project in the Great Lakes. In general, the components used in existing off-shore wind turbines are essentially the same as those used in terrestrial wind facilities. In fact, several turbine manufacturers, including Vestas and General Electric, use the same basic design for both their on-shore and off-shore models. As off-shore projects become more widespread, manufacturers could be expected to improve the technology by optimizing turbines to take advantage of the lighter towers and blades that may be used off-shore.

Although the turbines may be similar, the Study Group found that the design and installation of the foundations used to support off-shore wind turbines is much more complex than at terrestrial facilities, due to the climatologic, hydrologic, and geologic conditions presented by aquatic environments. The Study Group identified a number of unique conditions that could be faced by an off-shore project on the Great Lakes. Most significantly, these include the need to design foundations that can withstand the effects of winter ice formation on the Great Lakes, and the possibility of having to place turbine foundations at depths greater than those encountered by existing off-shore projects.

According to the National Oceanic and Atmospheric Administration, ice thickness ranges from .05 to 0.8 meters on Lake Superior and from 0 to 0.5 meters on Lake Michigan. Because existing projects are located in saltwater, there are no off-shore projects anywhere in the world that would be subject to similar winter ice conditions. Nonetheless, conical ice collars that are designed to break up ice at the point of contact have been used successfully on European wind turbine foundations, North American bridges, and other structures placed in the water. Thus, the

Study Group believes that existing technology would be sufficient to withstand the unique winter conditions in the Great Lakes.

Existing off-shore wind projects have generally been limited to waters that are less than 30 meters deep. These projects typically have used gravity, monopile, or suction bucket foundation designs. Depending on the geologic conditions at the project site, the Study Group believes that these designs could be readily adapted for use at similar in the Great Lakes. However, the vast majority of Lakes Michigan and Superior are deeper than 30 meters, and as noted, it is not known whether adequate wind resources exist in these shallow-water areas. Thus, it is likely that an off-shore wind project in the Great Lakes would require turbine foundation designs that could be installed in deeper water. While some deeper water foundation designs exist, such as a Scottish installation at a depth of 44 meters in the North Sea, most remain in the conceptual or demonstration phase. As a result, it may be necessary to develop the technology needed to place wind turbines at the depths and locations where the best wind resources occur in the Great Lakes.

Regardless of the depth at which a project would be located, the installation of off-shore wind turbines in the Great Lakes will likely require the use of specialized vessels, such as jack-up barges and barge-mounted cranes. However, the Study Group found that there are no vessels currently operating in the Great Lakes that are capable of constructing many of the turbine and foundation designs that were evaluated. Although some deep water foundation alternatives, such as floating platform designs, may eliminate the need for jack-up barges because the work could be performed by tug boats, these foundation designs are still in the development stage.

More importantly, the Study Group found that there would be significant obstacles to obtaining the necessary vessels from outside of the Great Lakes. First, jack-up barges are in high demand worldwide in the off-shore oil industry. The cost for a jack-up barge with sufficient capacity to erect a 2 MW turbine ranges from $50,000 to $60,000 per day, with additional costs of up to $19,000 per day for a crane. Second, federal law requires that ships carrying merchandise or passengers in the U.S. territorial waters or between U.S. ports be U.S. built and owned, and be documented by the United States Coast Guard. This precludes the use of a foreign-built or foreign-flagged ship to install the components of an off-shore wind turbine. Finally, even if a suitable U.S. built, owned, and operated ship could be located, its entry into the Great Lakes may be limited by the size of the navigation channels available through the St. Lawrence Seaway and the Chicago Sanitary and Ship Canal.

In addition to the design and installation concerns identified by the Study Group, an off-shore wind project would require a corresponding on-shore location known as a lay-down area to store the turbine components prior to assembly and installation. Because many of these components are currently manufactured in Europe and Asia, they would need to be shipped to a port in Wisconsin with adequate facilities to unload and store the components. The Study Group estimated that 30 wind turbines would require approximately eight acres for lay-down and additional area to pre-assemble some of the components before installation. However, the Study Group found that sufficient facilities would be available in Milwaukee, Green Bay, and Superior, and may be available in other Wisconsin cities along the Great Lakes.

Finally, as part of the project design, it is necessary to plan for the eventual decommissioning of the off-shore wind project, including determining whether the entire turbine foundation should be removed from the lake. The Study Group found that decommissioning an off-shore turbine would likely require similar equipment to that used for the initial project construction. In addition, an important element of project decommissioning will be to locate markets for the materials used in the turbine. Currently, there are developed markets for recycled concrete, steel, aggregate, and metals. In contrast, there is no market for the fiberglass blades used for wind turbines.

Evaluation of Transmission Infrastructure

An off-shore wind project will require the development of some transmission infrastructure to move the power to the energy market. This would include both off-shore and on-shore transmission facilities in the Great Lakes. The Study Group found that typically, off-shore turbines are connected by underwater cables to an off-shore collector substation, which increases the voltage prior to sending electricity to shore. The necessary transmission voltage depends on the size of the wind project, the distance between the substation and shore, and the voltage of the existing transmission system where the connection will be made. Depending on the project's size, one or more off-shore substations may be needed. The substation components, including the step-up transformer, would likely need to be mounted on a foundation similar to those used for the turbines.

In addition, one or more medium, high, or extra-high voltage cables would be needed to connect the off-shore substation to the on-shore transmission grid, depending on the amount of power generated off-shore. The cables connecting the turbines to the substation and linking the substation to the shore may either be buried in the lake bed or placed directly on the lake bottom. Because the technology for placing underwater cables is mature, the Study Group did not identify any unique technical or engineering concerns related to the installation or operation of transmission cables for an off-shore wind project.

Finally, the off-shore facilities will need to connect to the on-shore transmission system in order to move the electricity to market. The Study Group believes that Wisconsin's existing transmission system could support the development of smaller-scale off-shore wind projects less than 600 MW that are located near a city without substantial upgrades to the system. However, the projects larger than about 600 MW may require more substantial upgrades to the existing transmission system, including developing new transmission lines. The Study Group notes that regardless of whether an off-shore wind project is built, Wisconsin's transmission needs should be viewed in the context of larger regional plans and trends. These include the transmission of wind-generated power from the Great Plains to the eastern United States, the adoption of renewable portfolio standards by additional states, and the development of off-shore wind in the Great Lakes. Nonetheless, developing a transmission line parallel to Lake Michigan, either off-shore or on land, not only would help to support the development of off-shore wind projects but it would also help to better serve Wisconsin's existing load centers.

Off-Shore Wind Costs

The Study Group attempted to assess the relative costs of generating electricity using off-shore wind turbines compared to other energy sources, including terrestrial wind. However, it was difficult to estimate the cost to design, build, and operate an off-shore project in the Great Lakes because there are no off-shore wind projects currently built in North America. While several off-shore projects have been built in Europe, most are smaller than 100 MW and are located in shallow, saltwater environments where winter icing has not been a concern. Nonetheless, the Study Group relied heavily on the European experience to provide some insight into the expected costs of constructing, operating, and maintaining off-shore wind in the Great Lakes.

There are a number of factors that might tend to increase the cost of off-shore wind energy relative to other energy sources. First, wind turbine components and the materials from which they are made generally are in high demand worldwide, and this demand has driven up prices by as much as 85 percent since 2002.[1] Second, construction costs for off-shore wind turbines are expected to be higher than comparable terrestrial facilities, especially given the concerns noted by the Study Group related to placing turbine foundations in the deeper waters of the Great Lakes. Finally, operations and maintenance costs for off-shore wind turbines at European installations are higher than comparable land-based installations. This can be attributed to the need for specialized personnel and equipment to service the turbines, the additional time required to get to the project site, expected increased insurance costs, and the additional hazards presented by operating off-shore.

On the other hand, there are several factors that might tend to reduce the relative cost of energy produced from off-shore wind facilities. For example, because the Great Lakes offer the potential for larger wind installations, the economies of scale may help to reduce the relative cost of off-shore wind. Similarly, the presence of more consistent winds with higher speeds on the Great Lakes could be expected to result in more efficient operation of off-shore turbines compared to terrestrial projects. The efficiency of a wind turbine can be measured by its capacity factor, which is a comparison of its actual power production over a given time with the amount of power that could have been produced if the turbine had operated at full capacity for the same amount of time. Off-shore capacity factors are expected to improve as the technology and experience with their operation improves, which should serve to further reduce the cost/kWh for off-shore projects.

To illustrate the range of energy costs that could be expected from differing off-shore projects, the Study Group developed two hypothetical examples to demonstrate the possible range of construction costs. The first is a 200 MW project that would be built in shallow water five miles off-shore using existing technologies. When compared to a similarly sized terrestrial project, it is estimated that the construction costs for this project would be 140 to 200 percent more; the operations and maintenance costs would be 125 to 250 percent more. Assuming a 35

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[1] U.S. DOE Energy Efficiency and Renewable Energy. Annual Report on U.S. Wind Power Installation, Cost and Performance Trends: 2007. May 2008. http://www1.eere.energy.gov/windandhydro/pdfs/43025.pdf

percent capacity factor, the total cost of energy for this project is estimated to be \$0.112 to \$0.169 per kWh.

The second project is a 1,000 MW project built in deeper water located 20 miles off-shore. While some of the technology necessary for pursuing such a deep-water project is still in development, the more robust wind regimes anticipated 20 miles off-shore would result in a higher capacity factor for this project. For this project, construction costs were estimated to be 185 to 300 percent and operations and maintenance costs were estimated to be 125 to 250 percent of the costs for a similarly sized terrestrial project. Assuming a 40 percent capacity factor, the cost of energy was estimated to be \$0.126 to \$0.211 per kWh. These cost estimates could be expected to decrease significantly as deep water foundation technology improves.

Based on these estimates, it appears that, at least in the short term, the cost of energy generated from an off-shore wind will likely exceed the cost of energy generated from terrestrial wind projects. However, this assumes that there are no changes in current technology, policies, regulations, or energy prices. It should be noted that there was some disagreement among the members of the Engineering and Economics Work Group with respect to the estimation of the construction costs for the hypothetical off-shore wind projects. Nonetheless, the Study Group decided to include these cost estimates in this report because they represent the best available information and will be important for helping policy makers in evaluating the potential for developing off-shore wind resources.

Project Financing and Incentives

Based on the Study Group's estimates, the present-day differential between the cost of off-shore wind projects and terrestrial wind or fossil-fuel generation represents a significant challenge to the development of an off-shore project. However, if the State of Wisconsin decides to pursue the development of off-shore wind, it could provide financing or other incentives that would help to reduce the perceived risk and the cost premiums associated with off-shore wind.

A number of incentives for alternative energy sources already exist, but their availability depends on who is developing the project. If Wisconsin would like these incentives to apply to any type of developers of off-shore wind, legislative changes may be necessary.

In addition to those incentives that are already available, the Study Group also investigated financing options available for other types of energy projects. Examples of such financing alternatives that could be considered for off-shore wind development include the following: cost sharing and grants, tax-based incentives such as tax credits or accelerated depreciation, regulatory incentives, credit-based incentives such as securitized or lease generation financing, credit-based incentives, as well as RPS and purchase-power-agreement guarantee incentives. However, in most cases, state and/or federal laws would need to be changed to allow their use for an off-shore wind project.

Human Environment Issues

The Great Lakes are the single largest freshwater ecosystem in the world and are a unique national treasure. They support a diverse ecosystem upon which many plant and wildlife species depend and provide significant economic and recreational value to humans. The Human Environment Work Group was charged with identifying the potential effects, both positive and negative, of an off-shore wind project on the Great Lakes ecosystem and existing human uses of the Great Lakes. The most likely effects identified can be grouped into the following categories: effects on wildlife and aquatic life; terrestrial effects; and effects on human activities.

However, the Study Group found that without an actual project proposal, it is difficult to quantify the effects of an off-shore wind project in the Great Lakes. Because the effects of such a project will depend on the specific characteristics of a project, such as its size and location, the Work Group simply attempted to describe the range of effects on human uses and the natural environment that could be expected. Many of the potential impacts identified will require more detailed analysis.

To address this need, it may be beneficial for the State of Wisconsin to develop a generic environmental impact statement that identifies whether off-shore wind projects could be expected to have significant adverse environmental impacts. This would help policy makers in making informed regulatory decisions and would assist in the development of a site-specific analysis if an actual project is proposed. In addition, if the State decides to pursue developing a generic environmental impact statement for an off-shore wind project, it may wish to partner with other Great Lakes States, federal agencies, the wind power industry, and other interest groups to collect and share the data needed.

Effects on Wildlife and Aquatic Life

The potential effects of an off-shore wind project on wildlife and aquatic life, including migratory birds, bats, and fisheries, was one of the primary concerns identified by the Study Group. Specifically, many species of migratory birds and bats are known to follow the Great Lakes during peak migration periods from mid-April to late May and again from mid-August through late September. However, the details about the distribution, abundance, behaviors and movements of the various species are not well known. Additional research is needed to address gaps in the understanding of migratory bird and bat movements.

The Study Group found that it is difficult to determine the effects of off-shore wind turbines on fisheries and aquatic life because these may vary considerably depending on where a project is located. For example, a project located in a critical fish spawning area may have a larger impact than one that is located in areas that is not. In other cases, wind turbine structures could be designed to enhance habitat for some fish species. Nonetheless, the aquatic communities of the Great Lakes are under stress from multiple causes, including as aquatic invasive species and non-point source pollution. As a result, until more information is available, the Study Group believes that it is important to carefully evaluate project locations for their effects on aquatic ecosystems. Some factors that should be included in this evaluation include location of sensitive habitat such as spawning reefs, lake currents, aquatic invasive species, contaminated sediments, submerged logs, electromagnetic fields, noise, and the potential for spills of hazardous materials.

Terrestrial Effects

While the majority of the activity associated with an off-shore wind project will be located in the waters of the Great Lakes, the Study Group identifies some terrestrial effects that could be expected. For example, the construction of an off-shore wind facility may require the use of lay-down areas, staging areas, port facilities, and transmission system improvements. While none of these activities would be unique to an off-shore wind project, it is important that the effects of these activities on sensitive environmental, historical, cultural, or recreational areas be included in the evaluation of any off-shore wind project.

One possible negated effect that should be evaluated for an off-shore wind project is its aesthetic effects on the Great Lakes shoreline. People value the Great Lakes for many reasons, including its uninterrupted view from the shoreline, and visual and aesthetic effects have been a concern in the location of other wind projects. The Study Group found that the aesthetic effects of an off-shore project will vary depending on the site location, the size and number of the turbines used, the orientation of the project site, and any navigational or other display lighting used. Involving communities near a proposed off-shore project early in the process, including developing simulated photographs of the project site, may help the public better understand the visual impacts of a proposal.

In contrast, an off-shore wind project would not likely raise concerns about shadow flicker and turbine noise. Shadow flicker describes the effect of sunlight passing through rotating turbine blades. Because the effects of shadow flicker diminish significantly with distance from the turbine, this concern may be alleviated for projects located off-shore. Similarly, noise from day-to-day turbine operation or from an initial construction project may be less than a typical terrestrial project, and it will diminish the further a project gets off-shore. Generally speaking, human impacts that result from a wind project – whether it is terrestrial or off-shore – can be lessened through careful siting considerations.

Effects on Human Activities

The Study Group found that an off-shore wind project could potentially affect a number of human activities and uses of the Great Lakes, cultural and historic sites, commercial and recreational fishing, commercial and recreational navigation, air traffic, and communications. For example, there are numerous prehistoric and historic communities along the margins of the Great Lakes, as well as historically significant shipwrecks and other associated submerged features. Further, many of the region's Native American communities have a religious and historical linkage to the Great Lakes. The Study Group believes that the effects of a wind project on these activities could be minimized through careful selection of suitable project sites.

Lake Michigan and Lake Superior support sizeable commercial, tribal and recreational fisheries valued at over $1 billion. While most commercial and recreational fishing activities take place within roughly three miles of shore, some fishing activity occurs throughout Lake

Michigan and Lake Superior. The Study Group believes that it is important that any off-shore wind project maintain or enhance the economic and cultural components associated with these fisheries.

The Great Lakes are an important link in the nation's transportation infrastructure, are used by air traffic, and provide opportunities for recreational boating. While much of the recreational activity is relatively near-shore, the entire lake area is used at one time or another by recreational boaters. The United States Army Corps of Engineers (USACE) maintains navigation channels in the near-shore shallow waters of Lakes Michigan and Superior. Given the size of the Great Lakes, the Study Group believes that it would be possible to locate an off-shore wind project in a manner that would not significantly affect air traffic or commercial or recreational navigation. For example, effects on air traffic could be minimized by avoiding locations near airports, and hazards to navigation could be addressed by avoiding navigation channels and by marking the location of off-shore wind facilities on nautical charts.

The Study Group also investigated concerns that wind turbines on the Great Lakes could also interfere with various electronic signals and modes of communication, including radar and ship-to-ship communications. The draft environmental impact statement for a proposed project located in Cape Cod, Massachusetts, concluded that the project would have minor impacts on communications, because impacts would mostly be limited to within one half mile of the project site. Research and actual experience to date from operating off-shore wind projects in Europe appear to support this conclusion. For example, European experience has shown that off-shore turbines have some impact on marine radar systems, although there have been no documented safety problems. Nonetheless, the Study Group believes that such concerns can be minimized or eliminated through careful site selection and through conditions that may be placed on the operation of an off-shore facility during the approval process.

Legal Issues

The Study Group identified a number of potential legal issues related to the development of wind projects on the Great Lakes. Such projects would require a complicated review and multiple approvals under state and federal laws, as well as coordination and consultation among federal, state, local, and tribal governments. Although the State of Wisconsin would have the primary responsibility for regulating off-shore wind projects, due to its public trust responsibilities, it would be necessary to obtain federal approval as well. The primary regulatory agencies that would be involved in reviewing the project would be the PSCW, WDNR, and the USACE, although other agencies would have some responsibility for reviewing certain aspects of such a project. In addition, the Study Group found that it would be necessary to consult with Wisconsin's Indian tribes on any regulatory decisions related on off-shore wind projects that could affect tribal lands, rights or interests, such as fishing rights in Lake Superior.

While existing law does not appear to prohibit the development of wind energy in the Great Lakes, there are uncertainties about whether existing regulatory authorities are sufficient to allow such projects to proceed. Most significantly, it is unclear whether the placement of the necessary infrastructure on the beds of the Great Lakes could be permitted under existing Wisconsin law. Although current state law authorizes the placement of electric transmission facilities on submerged lands, there are questions about whether the placement of other structures, such as wind turbines, could be authorized under existing statutory processes.

The Work Group identified three mechanisms under which the State may possibly authorize the placement of certain structures on the beds of the Great Lakes:

1) Public utilities, as defined in Wis. Stat. §196.01(5), may seek a permit from the WDNR to construct utility facilities on the beds of the Great Lakes under Wis. Stat. § 30.21.
2) Riparian landowners, including municipalities, who own land adjacent to a navigable water body, may seek approval from the WDNR to place structures or deposit materials on the beds of navigable waters under Wis. Stat. § 30.12.
3) Lakebed grants may be made by the Legislature to public entities, including local units of government, for public trust purposes under Wis. Stat. § 13.097.

If the Legislature were to expand their purpose, lake bed leases under Wis. Stat. § 24.39 could provide a fourth pathway for such projects. However, none of these mechanisms have been used to permit a similar type of project in the Great Lakes. It may be beneficial for the Wisconsin Legislature to address the legal questions--including findings related to the public trust doctrine--about the placement of wind turbines in the Great lakes, to clarify which entities may apply for permits, and to address the standards for siting and permitting off-shore projects.

Another concern identified by the Study Group is whether a proposed off-shore wind project in the Great Lakes would be subject to oversight and approval by the PSCW under existing law. In general, the PSCW has the primary jurisdiction for reviewing and approving electricity generation and transmission facilities in Wisconsin. However, projects that are smaller than 100 MW and are proposed by entities other than public utilities do not require PSCW approval. As a matter of policy, it may be beneficial to ensure that any off-shore wind project require a certificate of public convenience and necessity from the PSCW.

Finally, due to the number of overlapping federal jurisdictions and federal laws that would be involved with a review of off-shore wind projects in the Great Lakes, it may be beneficial for a single federal agency to serve as the lead agency for coordinating the federal review of such projects in the Great Lakes, similar to the procedure used for reviewing energy projects on the Outer Continental Shelf. Because the USACE has significant jurisdiction for projects that occur in navigable waters under the Clean Water Act and the Rivers and Harbors Act, as well as experience with other large-scale projects in the Great Lakes, it may be appropriate to designate this agency to serve in this role.

Community Involvement Issues

The Community Involvement Work Group conducted a variety of activities to gauge the initial public reaction to the concept of an off-shore wind project. However, its investigation spurred little public feedback about off-shore wind during its course. The public input that was received during the course of this investigation leaned heavily towards interest in more information about wind power in general. Specific community interest and inquiries are likely to increase when an actual project is proposed at a Great Lakes location.

The selection of a project location should be and will be a driver in community involvement. Project developers should expect to engage the communities near a potential off-shore wind project early and often.

Conclusion

The Study Group found that while off-shore wind projects are technically feasible and represent one potential approach to meeting a portion of the state's long-term energy needs, the development of such projects in the Great Lakes will require a coordinated effort by state and federal agencies, local government, affected Indian Tribes, and possibly the Wisconsin Legislature. Should the PSCW decide to continue its investigation of off-shore wind development in the Great Lakes, the likely next step would be to collect wind resource, wildlife, and other ecological baseline data at specific lake sites. The off-shore capacity factors will be one of the fundamental economic drivers for these projects and will help to define the risk for the first Wisconsin project. Other possible next steps could include the following:

- further investigate and promote research and development on deep water foundations;
- initiate discussions with local ship builders, other states and Canada on procuring a construction vessel for the Great Lakes; and
- begin working with the Wisconsin Legislature to consider legislative changes that would facilitate the development of off-shore wind on the Great Lakes.

While tapping the vast wind resources on the Great Lakes has the potential to create significant quantities of renewable energy for Wisconsin, further investigation may be required before moving forward with a large scale project.

2. INTRODUCTION

Wisconsin has few native energy resources, with the exception of renewable energy sources such as wind, hydroelectric, and biofuels. Instead, Wisconsin currently generates a large majority of its in-state energy from non-renewable sources, and it imports all of the natural gas, coal, and uranium used to generate electricity in the state. Furthermore, Wisconsin is a net energy importer that spends approximately $9 billion each year to meet its energy needs. With heightened concern about global warming, fuel supplies, and price volatility, exploring in-state renewable energy sources is a necessity. By the end of 2008, Wisconsin will be home to wind projects with a total rated capacity of 449 MW.[2] A list of current Wisconsin wind power sites is provided in Appendix G. Recently, Wisconsin's renewable energy usage has grown, in large part due to the State's renewable portfolio standard (RPS) of producing ten percent of our electricity from renewable energy sources by 2015. However, within the last year, both Governor Jim Doyle and the Governor's Task Force on Global Warming have recommended a RPS of 25 percent by the year 2025 with ten percent of total retail electric sales coming from renewable resources within the state. The Task Force further recommended that, no later than December 31, 2008, the Public Service Commission of Wisconsin (PSCW) and other state agencies complete a study of the potential for developing off-shore wind resources in the Great Lakes.

On April 3, 2008, the PSCW opened Docket 5-EI-144 to commence a Great Lakes Wind Study to look at the technical feasibility, economic potential and environmental impacts of developing wind energy on Lake Michigan and Lake Superior. PSCW collaborated with the Department of Natural Resources (WDNR), the Board of Commissioners of Public Lands (BCPL), and the Department of Administration (DOA), to establish and convene a study group. The main study group ("Study Group") met numerous times to plan the investigation, share information, and discuss conclusions. Four Work Groups were established to look more closely at specific issues: Engineering & Economics, Human Environment, Legal and Community Involvement. Each Work Group also met numerous times. The Study Group and the four related Work Groups conducted their business publicly. All meetings were open to the public, and documents were shared via the PSCW website. This report represents the final work product of the Study Group. Members of the Study Group and the related Work Groups are identified in Appendix A.

2.1 Options to Meet Wisconsin's RPS

Moving Wisconsin away from its reliance on fossil-fuel energy generation towards a more diverse and renewable energy portfolio will help to achieve carbon emission reductions and the net environmental benefits envisioned by the Task Force. However, Wisconsin's move towards greater energy independence must be balanced with a careful exploration of the state's various renewable energy options, with a focus on developing renewable energy resources efficiently and responsibly. Such an exploration should include careful consideration of market and technology maturation, assessment of available transmission infrastructure, evaluation of

[2] Wisconsin's first modern, low-speed wind turbines were installed in 1998 essentially as a demonstration project.

costs and impacts on Wisconsin's ratepayers, thoughtful examination of environmental and community impacts and analysis of how the legal framework may enable or impede a renewable energy project. These renewable energy development criteria are largely the topics that fueled this off-shore wind investigation in the past year.

If an expanded RPS with a ten percent in-state renewable energy requirement is adopted in Wisconsin, the amount of renewable electricity that Wisconsin will need to generate over the coming years is substantial. Electrical energy sales in Wisconsin in 2006 totaled about 70,000,000 megawatt-hours (MWh). The Task Force commissioned computer modeling that forecasts this number will grow to about 106,000,000 MWh in 2025 if no new policies are adopted or about 85,000,000 MWh in 2025 if the Task Force's energy conservation and efficiency recommendations are adopted. To meet the in-state RPS goal proposed by the Task Force, state electric utilities would need to produce at least 8,500,000 MWh of electricity in 2025 from renewable energy resources located in Wisconsin.

Many utilities are currently implementing a number of wind projects to help them meet the State's RPS. Unless technological breakthroughs occur in other sources of renewable energy, this trend is expected to continue. However, the reliance on wind power to meet the State's RPS raises two important policy questions. First, to what extent should utilities rely on in-state versus out-of-state wind resources? And second, if in-state resources are to be developed, to what extent should off-shore wind resources be pursued compared to terrestrial wind projects? Since the Global Warming Task Force has recommended that ten percent of the total retail electric sales be fulfilled with in-state renewable energy sources, the first question may be answered by the Legislature. This report primarily addresses the second question by examining the potential development of off-shore wind projects in the Wisconsin waters of Lakes Michigan and Superior.

2.1.1 Out-of-State (Terrestrial) Wind

One of the alternatives to off-shore wind development in the Great Lakes is to import more electricity from terrestrial wind projects in the northern Great Plains states, which have better terrestrial wind resources than Wisconsin. Many wind projects have been built and many more are being proposed in those states, particularly in western Minnesota, Iowa and South Dakota. Based on recent projects, the all-in[3] production cost of out-of-state terrestrial wind is estimated to be $0.08 to $0.10 per kilowatt hour (kWh)[4]. Imported wind power will undoubtedly help Wisconsin meet its current RPS target and the overall RPS targets proposed by the Task Force.

While terrestrial wind outside Wisconsin's borders may prove more efficient than developing terrestrial wind projects in-state due to higher wind speeds, importing out-of-state wind has several disadvantages. First, tapping into out-of-state wind will not help Wisconsin utilities meet the in-state RPS requirement. Second, by looking outside the state for renewable

[3]All-in production costs include the following: capital costs of the project (equipment and installation), operation & maintenance costs, overheads and likely transmission-associated cost.
[4] The cost range estimate reflects PSCW staff's review of modeling done for out-of-state wind projects. They include costs that would be associated with transmission and line losses.

energy solutions, Wisconsin may also lose local job growth and economic development potential. Finally, projects in the Great Plains are a long distance from Wisconsin's electric load centers. This leads to problems with congestion and losses in the transmission system, which may increase the cost for electricity and offset some of the economic benefit resulting from utilizing higher capacity terrestrial wind projects outside of Wisconsin.

2.1.2 In-State Terrestrial Wind

The strength of wind resources are rated on a scale from one to seven with seven being the best resource. The best terrestrial winds in Wisconsin are rated Class 3.[5] Although Wisconsin's terrestrial wind resources are not as robust as other Midwestern states, there are key areas in Wisconsin where terrestrial wind power is feasible. Based on recent projects, the estimated all-in[6] production cost of in-state terrestrial wind ranges from $0.10 to $0.12 per kWh[7].

2.1.3 Off-Shore Wind in Wisconsin

In contrast to Wisconsin's marginal terrestrial wind, winds off-shore in Lake Michigan are rated Class 3 to 6, which are comparable with the wind resources measured in the Great Plains. Additionally, those Great Lakes wind resources are located near some of the state's population and electricity-demand centers making off-shore wind more attractive for meeting the RPS.

By the end of 2008, four terrestrial wind projects, which could produce 1,000,000 MWh per year of electricity, will be on-line in Wisconsin. Moreover, the state's hydroelectric power stations have historically produced more than 1,500,000 MWh per year. Assuming those generators continue through 2025, Wisconsin would need an additional 6,000,000 MWh per year of in-state renewable generation to meet a ten percent in-state RPS. If Wisconsin chooses to rely on wind to meet its RPS target, robust off-shore winds may prove to be a viable alternative. While more wind data is needed, the consistency of off-shore wind in the Great Lakes may approximate the intermediate energy generation resources Wisconsin now uses.[8] Using an estimated average net capacity factor of 38 percent for wind turbines on Lakes Michigan and Superior, 1,800 MW of off-shore wind capacity might be sufficient to meet the in-state RPS goal, even if no other renewable resources are constructed.[9]

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[5] This classification is based on the average annual wind speed measured at 10 meters (33 feet).

[6] All-in production costs include the following: capital costs of the project (equipment and installation), operation & maintenance costs, overheads and likely transmission-associated cost.

[7] This cost range estimate is based on EGEAS modeling runs prepared for the Commission's draft 2008 Strategic Energy Assessment, docket 5-EI-104.

[8] For example, an intermediate load source such as a natural gas-fired, combined-cycle (CC) power facility has a capacity factor that can range from 20 to 60 percent. Though wind is not dispatchable, this limitation diminishes with higher capacity factors. As the capacity factor increases into the 40 percent to 50 percent range, wind generation begins to mimic conventional generation resources.

[9] An analysis of the capabilities of off-shore wind turbines suggests that a net capacity factor of 38 percent may be a conservative assumption for a project located on Lake Michigan or Lake Superior. This topic is covered in greater detail in Chapter 3 of this report.

The amount of lake area required for a hypothetical 1,800 MW off-shore wind project on the Great Lakes can be estimated based on information from other off-shore projects. The Engineering Work Group estimated that the proposed *Cape Wind* off-shore project in Massachusetts would have a density of about 18 MW per square mile. A similarly designed 1,800 MW project constructed on Lake Michigan would require 100 square miles. Although this would be an extremely large project, it should be noted that the total surface area of Lake Michigan is 22,350 square miles. The hypothetical project would affect less than half a percent of the lake's surface.

Though heavily debated by the Study Group, a calculated range for all-in production costs of off-shore wind are estimated to likely fall between $0.112 to $0.169 per kWh for a shallow water site or $0.126 to $0.211 per kWh for a deep water site.

While this report enumerates the challenges of developing off-shore wind, the benefits of wind generation should not be overlooked. Wind generation has numerous environmental benefits over fossil fuel generation including significant reduction in the emission of air pollutants, in the production of solid waste, and in the consumption of water. Appendix C provides a brief description of the benefits of wind generation over fossil fuel generation.

2.2 Benefits of Off-Shore Wind Over Terrestrial Wind

Although Wisconsin continues to develop familiarity with terrestrial wind resources in bringing inexhaustible, domestically-produced clean energy to the citizens of Wisconsin, less is understood about off-shore wind power in the state. One of the primary benefits from off-shore wind projects is the significant increase in energy output of wind turbines located off-shore. This is attributable to more robust wind energy resources in off-shore locations and the ability to construct and site much larger turbines off-shore.

Generally, off-shore project locations will have more consistent, higher speed, and better quality wind resources than terrestrial locations. The reason is that wind speed increases over bodies of water. Reduced turbulence, increased wind speeds, and steadier wind conditions will result in highly productive and strong output from wind projects located in what are arguably some of the best wind sites in the U.S.

In the case of the wind turbines themselves, off-shore wind locations are much more amenable to larger wind turbine installations than typically seen on land. The typical size of land-based turbines in the U.S. ranges from 1.5 to 2.3 MW turbines, while some planned off-shore projects are projecting the use of a 5 MW or larger turbine. One advantage comes from longer turbine blades which increase the "swept area" traversed by the rotating blades. In the future, taller towers and hub heights may allow better wind resource utilization at higher elevations above the surface of the water. Larger turbines can be installed in off-shore locations more readily, in some cases, than land-based locations due to geographic or transportation limitations. While the transport and construction of off-shore wind turbines involves a new set of logistical challenges, this may be offset by the ability to use the largest turbines now being constructed.

Furthermore, in some locations of the U.S., there is increased correlation between off-shore power production and electricity loads, as compared to land-based wind turbine power production. This will need to be studied further for the off-shore locations in Lake Michigan and Lake Superior. In addition to the issue of wind speed, off-shore wind power appears to have an advantage over terrestrial, in-state wind power in addressing at least three concerns frequently raised in environmental impact statements: noise impacts, shadow flicker, and electromagnetic frequencies. Each of these topics is discussed in greater detail in chapter five. The combination of better wind resources and larger wind turbine sizes in off-shore projects may offset the challenges, risks and likely initial higher costs associated with off-shore wind. While certain technical and legal challenges exist, off-shore wind projects in Lake Michigan and Lake Superior have the potential to produce power economically and on a large scale to eventually become a major contributor to the electricity supply for the State of Wisconsin.

The benefits of off-shore wind may also extend into economic development issues. The ability of terrestrial wind power projects to create jobs is well documented, but less is known for off-shore wind especially in the U.S. As will be detailed in chapter three of this report, off-shore projects require specialized vessels and other specific equipment that currently may not be available in the United States or may be in high demand. If the off-shore wind industry takes off in the Great Lakes region and elsewhere, Wisconsin could potentially see new and increased manufacturing and export opportunities, not just in the wind power components industry but perhaps in the shipbuilding industry as well. But manufacturing jobs only tell part of the story. The development of off-shore wind projects in the Great Lakes could also mean new jobs in construction and installation near project locations and, as has been seen in Europe, boosting of the economy in port cities and communities with marine industries. The deployment of off-shore wind energy might give a strong boost to job creation and regional development for Wisconsin communities near off-shore wind sites. The potential for the creation of well-paying jobs in sectors that support wind development, such as manufacturing, engineering, construction, transportation, and financial services stands to be lucrative.

3. Off-Shore Wind Project Basics: Foundations, Turbines, Construction, Lake Conditions and Transmission

This chapter provides an overview of engineering, cost and transmission issues associated with the development of wind projects on Lakes Michigan and Superior. It offers an overview of wind resources on the two lakes and issues to be addressed in building an off-shore project, particularly winter ice conditions. There is a discussion of the construction requirements, turbines and foundation designs that could be used on the lakes, including deeper off-shore sites. There is also an explanation of the transmission requirements associated with connecting an off-shore wind project to the transmission grid, and an assessment of the existing transmission system near the shore lines of both lakes and its ability to support off-shore wind development. Finally, there is a discussion of transmission planning at the state and regional levels and how these could affect the development of off-shore wind.

3.1 Foundations

The wind turbine foundation is a critical design element whether the wind turbine is installed on land or water. Wind turbine foundations designed for off-shore installations are more complex from a design and installation perspective than on-shore foundations. The main reasons for the increase in complexity include loadings unique to off-shore wind turbines, such as wave loading, static and dynamic ice loading, water depth and water currents. These additional loads require more rigorous analysis and modeling to simulate the various load impacts on the foundation.

To date, the industry has favored simple and robust solutions over unproven high-tech solutions. These foundations have been used in water depths, considered shallow water, ranging from three to 30 meters. Most of the shallow water foundations are adaptations of on-shore foundation technologies. Deep water (greater than 30 meters) foundations are in a conceptual and demonstration phase because there are no large-scale deep water wind projects in operation. Many of the deep water foundations being evaluated are technologies adapted from the gas and oil exploration industry. These technologies hold various levels of promise and are discussed below.

Installing an off-shore wind turbine foundation is complex due to weather limitations on equipment, wave action, and increased wind off-shore. Much of the equipment used in off-shore installations is sensitive to wave action, especially the smaller support vessels. Larger vessels, such as jack-up barges, may be less sensitive to wave action, but their activities may still be curtailed by wind limitations on the installation crane. Additionally, jack-up barges or specialized barges required for off-shore installations are costly to build, already in high demand in the gas and oil industry, and have width restrictions for entering the Great Lakes.

3.1.1 Shallow Water Foundations

There are various types of foundations that can be utilized in water depths of three to 30 meters, considered shallow by the off-shore wind turbine industry. Over the last 15 years shallow water foundations have been installed at various projects in Europe off the coasts of Denmark, England, Netherlands, Scotland, Germany, and Sweden. The three primary foundation types are gravity, monopile and suction bucket.

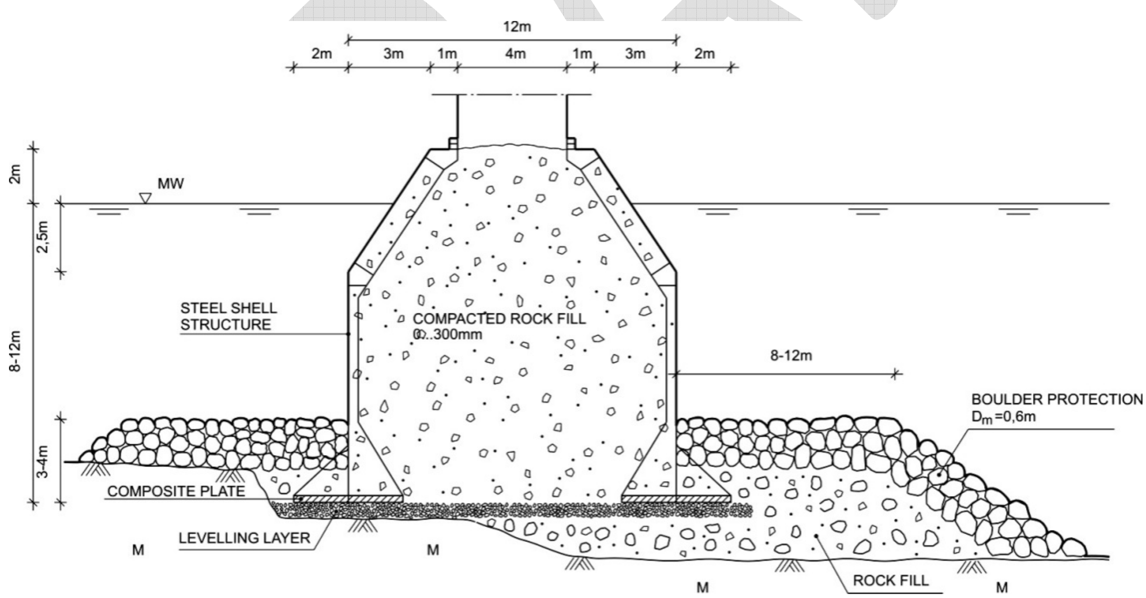
3.1.1.1 Gravity

The gravity foundation is an adaptation of the most common on-shore wind turbine foundation - the inverted tee foundation. On land, once soil bearing design is taken into consideration, this foundation is designed to withstand maximum design loads primarily using the foundation and backfill soil weight to withstand overturning moments and sliding.

The primary differences between off-shore and on-shore gravity foundations is that the off-shore gravity foundation requires special bed preparation, is placed on top of the bed versus being backfilled with soil, and needs to extend near or above water level for the transition piece/wind turbine connection.

Both steel and concrete gravity foundations have been installed as off-shore wind turbine foundations. Steel gravity foundations are considerably lighter than concrete foundations and are normally filled with granular material (rock, gravel, or sand) once placed off-shore. The steel gravity foundations can also be modified with conical collars (ice cones) to reduce ice loading impacts.

Figure 3.1: Steel Gravity Foundation



Source: ESA Eranti: Eranti Engineering Oy. Espoo. Finland

Concrete gravity foundations are heavier than steel gravity foundations and are a well known technology. The primary difficulty with concrete gravity foundation is handling due to their heavy weight. These foundations may also be modified with ice cones.

Both steel and concrete gravity foundations had previously been seen as cost prohibitive when evaluated for installations deeper than 15 meters. They are now being examined for installations of 30 meters and deeper.

3.1.1.2 Monopile

Monopiles are the most commonly used shallow water off-shore foundation. The monopile is a large, thick-walled, single steel pipe that is driven into the bed of a water body at a predetermined depth.

Monopile installation requires large barges that use specialized equipment to drive the piles into the lake bed. Monopile transition pieces can be modified to create ice cones. The transition pieces can be steel, concrete or composite (steel/concrete) structures.

3.1.1.3 Suction Buckets

Suction bucket or caisson foundations are a new technology for shallow water foundations. The suction bucket is a tubular steel foundation that is installed by sealing the top of the steel bucket and applying a vacuum (suction) inside the bucket. The hydrostatic pressure difference and the dead weight of the structure cause the bucket to penetrate the soil.[10]

Usually, the suction buckets are attached to foundation structures that connect to the wind turbine. Suction buckets have been used at oil and gas fields in the North Sea and Angola. The first full-scale wind turbine prototype suction bucket foundation was installed in October 2002 in Denmark.[11] Suction buckets can also be used in concert with deeper water foundation options.

3.1.1.4 Comparison of Shallow Water Foundation Types

The table below summarizes the advantages and disadvantages of the shallow water foundations discussed. The table includes a modification of a concrete gravity foundation that could be used in ice environments such as the Great Lakes.

[10] Dutch Off-shore Wind Energy Converter Project, "Suction Bucket Foundation", http://www.ecn.nl/docs/dowec/10061_003.pdf

[11] http://vbn.aau.dk/research/prototype_bucket_foundation_for_wind_turbines(6396351)/

Table 3.1: Advantages and Disadvantages of Shallow Water Foundations

Foundation Type	Advantages	Disadvantages
Concrete gravity base foundation	• Well-known technology. • Can construct on-shore and float to site. • Rigid tower base. • Can add conical section at top to act as ice breaker.	• Size/weight. • Decommissioning/removal. • Special foundation preparation may be required – depending on soil type. • Foundation toe needs scour protection.
Steel gravity foundation	• Considerably lighter than concrete foundations. • Low weight of steel cylinders allows more rapid foundation installation. • Foundation can be made onshore. • No piling. • Can be removed completely and repositioned. • Can be easily inspected.	• Cylinder needs to be filled with granular material to withstand waves and ice. • Need to install erosion protection around foundation base. • Time consuming weld details. • Need large laydown area to construct.
Thin-walled cylindrical shell with ring footing – conical shape and filled with granular material (steel gravity foundation)	• Designed for areas with waves and ice ridge action (for example Baltic Sea and Great Lakes). • More rigid than a pile structure. • Steel shells can be transported by barge. • 50-year design life.	• Needs firm/hard bed conditions. • Erosion protection required. • Cylinder needs to be filled with granular material to withstand waves and ice.

Table 3.1: Advantages and Disadvantages of Shallow Water Foundations (Continued)

Foundation Type	Advantages	Disadvantages
Monopile foundation	• No bed preparation required. • Relatively simple to manufacture and construct. • Foundation flexibility enables tuning of structure dynamic characteristics. • Quick installation. • Low sensitivity to underwater erosion.	• Requires specialized installation equipment. • Sensitive to rocks when driven. • Not suitable for weak soils. • Difficult to modify for ice protection. • Price increases with respect to depth more rapidly in areas with ice pressure concerns.
Suction caisson	• Simpler/quicker construction procedure. • Less/smaller installation equipment required. • Easy to remove. • Inexpensive installation.	• New technology. • Proven only in limited range of materials.

3.1.2 Transitional/Deep Water Foundations

At water depths greater than 30 meters, foundation technology transitions from traditional, shallow water foundations to more robust fixed foundations used in waters between 30 to 50 meters and various floating technologies that are being planned for waters deeper than 50 meters. The floating technologies vary but usually include a combination of ballast, mooring line, or buoyancy stabilization.

3.1.2.1 Tripod/Tetrapod Foundations

Tripod (three support legs) and tetrapod (four support legs) foundations for wind turbines have been adapted from technologies used by the oil and gas industry. The tripod has a main steel pile to which the turbine is attached. A steel framing extends from the pile and attaches to legs that anchor the foundation to the water body bed. The legs can be secured to the bed by driving piles 10 to 20 meters in the soil or by using suction buckets. The pile driving depth will be determined by geotechnical conditions.

This technology has not been used on many wind turbine projects to date. The tetrapod concept (OWEC Jacket Quatropod) is being demonstrated at the Talisman-Beatrice project. It is being characterized by its designers as having a unique design element, lower weight, the ability to support large turbines - up to five MW, and the ability to be installed in difficult locations with poor soil conditions.[12]

[12] http://www.owectower.no/quattropod/index.php

Another derivative of the tripod foundation technology is the Titan Wind Turbine Platform. This technology is a mobile self-installing platform that sits on three legs. This concept allows the turbine to be installed and commissioned on the Titan Platform in port. After assembly, the platform can be towed to its design location, and then the three legs of the platform can be lowered to the bed and ballasted into the soil – similar to a jack-up barge. This design also creates a gap between the water and platform that enables the turbine base to stay above wave action.[13]

Figure 3.2: The Titan Wind Turbine Platform

Source: Off-Shore Wind Power Systems of Texas LLC, USPat. 7163355

The Floating to Fixed (F2F) Wind Energy Concept is a solution that utilizes ideas similar to the Titan Wind Turbine Platform. F2F would enable the wind turbine to be installed and commissioned in port, towed to the off-shore location, lowered to the water body bed by ballasting, fixed to the bed by suction anchors, and, if necessary, refloated and towed to port for repairs.[14] The design for F2F was completed in 2007 and the next step is for a prototype to be built.[15] Installation depths for this concept are expected to be comparable to the tripod foundation, ranging from 30 to 50 meters.

[13] Titan 200 Turbine Platform, Off-shore Source LLC, http://www.off-shorewindpowersystemsoftexas.com/titan_200_deep_off-shore_platform
[14] http://www.seaofsolutions.nl/Info%20sheet%20F2F%20concept.pdf
[15] http://renewenergy.wordpress.com/2008/04/25/floating-off-shore-wind-opens-up-the-deep/

3.1.2.2 Floating Foundations

Floating foundations for wind turbines are in the conceptual phase, but if successful, offer opportunities to install wind turbines in water depths greater than 50 meters. Installing wind turbines in the deeper water of the Great Lakes would enable the exploitation of better wind resources farther off-shore. There are multiple floating foundation technologies being evaluated at this time. Some of these technologies include the Dutch Tri-floater, tension leg platform, WindSea, Blue H Technology, HyWind and SWAY concept. All the concepts listed are stabilized using some combination of buoyancy, mooring lines, and ballasting.

The Dutch Tri-Floater Foundation uses distributed buoyancy tanks attached to the central tower through truss arms. It also incorporates moorings attached to the bed by suction pile anchors to provide additional resistance to overturning.[16]

The tension leg platform technique is adopted directly from the oil and gas industry. The concept evaluated by the National Renewable Energy Laboratory (NREL) utilizes a single cylindrical buoyancy tank that connects to the turbine base below normal water level. Three radial arms extend from the tank. At the end of the arms are connection points for tendons that are anchored in the bed.

WindSea is a Norwegian concept that would enable up to three turbines to be installed on one structure. The estimated water depth for WindSea placement is 35 to 200 meters. Current estimates are that a prototype will be placed in 2011.[17]

Blue H Technology differs from other deep water foundation options because it utilizes a large steel structure using the Submerged Deep-Water Platform concept. The structure is towed to its operating location from port and attached to the bed using the tension leg platform concepts of mooring and buoyancy stabilization. Blue H Technology launched the first large scale prototype off the coast of Italy in December 2007, and will be anchored in 108 meters of water.[18]

[16] http://www.nrel.gov/docs/fy04osti/34874.pdf
[17] http://renewenergy.wordpress.com/2008/04/25/floating-off-shore-wind-opens-up-the-deep/
[18] http://www.bluehgroup.com/company-newsandpress-0712062.php

Figure 3.3: Blue H Technology, a Deep Water Foundation Option

Source: Blue H Group

HyWind is a concept being developed by StatoilHydro of Norway that claims to be the world's first large-scale floating wind turbine. The concept utilizes the spar buoy technology that is currently used on oil production platforms and off-shore loading buoys. The planned startup of HyWind is scheduled for the fall of 2009. It can be placed in water depths ranging from 120 to 700 meters. The spar buoy will be attached to the sea bed using three anchor moorings.[19]

The SWAY concept is based on a floating elongated pole extending far below the water surface with ballast located at the bottom part of the structure. This concept is being developed in Norway and can be placed in water depths of 80 to 300 meters. Capital is currently being raised to support placement of a prototype. Current applications are supplying power to existing oil platforms in the North Sea (Talisman-Beatrice) or exported to on-shore markets.[20]

3.1.2.3 Comparison of Transitional and Deep Foundations

The primary advantage to developing deep water wind turbine foundation options is gaining access to better wind resources. Additionally, many of the deeper water foundation technologies offer installation processes that eliminate the need for large off-shore vessels and

[19] http://www.statoilhydro.com/en/NewsAndMedia/News/2008/Pages/hywind_fullscale.aspx
[20] http://sway.no/

potential towing back to shore for major maintenance activities. However, deeper water foundations have not yet been used at commercial scale for wind turbines.

Table 3.2: Off-Shore Foundation Advantages and Disadvantages

Foundation Type	Advantages	Disadvantages
Tripod/tetrapod foundation	• Applicable to deeper water. • No or limited seabed preparations. • Can be built on-shore. • Easy to remove.	• Increases ice load. • Boat access difficult. • Sensitive to rocks when leg supports are driven.
Titan Wind Turbine Platform	• Tug boat deployable. • Can be installed in uneven terrain. • Lower installation and decommissioning costs. • Easy to remove for maintenance or decommissioning.	• Not demonstrated on a large-scale wind project. • Boat/personnel access elements need to be incorporated. • Ice loads require evaluation and modification to legs post-installation.
F2F Wind Energy Concept	• Tug boat deployable. • Can be used with suction buckets to minimize lake bed disturbances. • Can be maintained at port.	• Not demonstrated on a large-scale wind project. • Uncertain cost. • Ice loading will need to be evaluated.
-Dutch tri-floater -Tension Leg Platform	• Tug boat deployable. • Turbine siting and interconnection flexibility. • Can be maintained at port.	• Not demonstrated on a large-scale wind project. • Uncertain cost. • Ice loading will need to be evaluated.
-WindSea -Blue H Prototype -HyWind -SWAY	• Install in deeper water depths.	• Not demonstrated on a large-scale wind project. • Uncertain cost. • Stability, access and structural fatigue issues need to be analyzed.

3.1.2.4 Lack of Deep Water Experience

There are various deep water foundation options that are at different stages of evaluation. These concepts, though familiar to the oil and gas industry, are being redesigned to become cost effective and compatible with existing wind turbine technologies.

Of the nine concepts discussed in the transitional/deep water foundation section, only two have made it as far as the prototype phase, the tetrapod at Beatrice-Talisman and Blue H off the coast of Italy. The Beatrice-Talisman project is the only project generating electricity that is connected to an end-user and employs full-scale five MW wind turbines. There are prototypes planned for the other concepts in future years, but the commercial viability for floating foundations is uncertain.

3.1.3 Foundation Design in the Great Lakes and Ice Loading

One of the key considerations in designing off-shore wind turbine foundations in Lake Michigan and Lake Superior is the loading from ice floes on turbine foundations.[21] There are existing wind projects in Europe that have been designed to withstand icing environments. The severity of the icing at wind projects in Europe vary from moderate icing along the western coast of Denmark to more extreme icing conditions along certain areas of the Baltic Sea.

The primary response to offset the forces exerted by ice floes on piers and foundations in water has been to install conical shaped structures at water level. The cones cause ice to bend and break up as it makes contact with the structure. They are widely used to reduce static and dynamic ice actions in wind turbine foundations, bridge piers, and other water based structures.[22]

For example, the Confederation Bridge project located in the Northumberland Strait between New Brunswick and Prince Edward Island in Canada, shows that piers and foundations can be designed to withstand extreme ice pressures. The project incorporated load sensors and cameras to record surface ice floe behavior against the conically shaped bridge piers. Data has been collected since 1998. Through 2007, including one extreme event, the experienced loads were within the design factor of safety and below what would have been calculated with existing formulas, supporting the idea that the theoretical calculations used are reasonably conservative.[23] This and other sets of analytical data could make design standards concerning ice forces more efficient, which would enable more cost effective, yet safe, designs.

The Confederation Bridge ice loading is higher than what would be anticipated in either Lake Superior or Lake Michigan. Maximum ice thickness ranges from 0.05 to 0.8 meters on Lake Superior, 0.2 to 0.7 meters on Green Bay, 0 to 0.5 meters near shore Lake Michigan, and 0 to 0.15 meters in waters deeper than 20 meters on Lake Michigan.

Existing technology could be used to design a foundation to withstand ice conditions on the Great Lakes. Information from projects like the Confederation Bridge will enable design standards in icing environments to become better optimized. Additional sources of ice loading design criteria will come from agencies that have been designing, building, and maintaining structures in the Great Lakes environment such as the United States Army Corps of Engineers

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[21] Other important foundation design criteria are lake bed geotechnical conditions, underwater currents, water level, lake bathymetry, wave height, and wind and wave loads.

[22] An example of ice floe design criteria would be from the Middelgrunden project in Denmark. For this project's conditions, foundations were designed for a 0.6 meter thick drifting ice-floe of 2 meters by 2 meters, moving with a speed of 0.6 meters per second. The design solution was an ice cone at the level of sea surface. The ice cone will reduce ice loads by a factor of 5 to 10, meaning that ice loads (at this project's location) are not the design driver any more. They also determined that ice will become a less critical design criterion if turbines increase in weight. http://www.middelgrunden.dk/MG_UK/project_info/mg_40mw_off-shore.htm

[23] Confederation Bridge Ice Force Monitoring, Presentation by T.G. Brown, Department of Civil Engineering, Schulich School of Engineering, University of Calgary, Calgary, Alberta, Canada, ASCE Spring 2008.

(USACE). Other sources, among many, that may provide design guidance concerning ice loading criteria include the International Society of Off-shore Engineers and the Geophysical Institute.

3.2 Wind Turbine Technology

This section discusses off-shore wind turbine technology including the turbine and tower. Topics covered are: current technologies, comparison with on-shore technology, estimated capital costs, and operations and maintenance (O&M) methods and costs.

3.2.1. Differences between On-shore and Off-shore Wind Turbines

There are few technological differences between on-shore and off-shore utility-scale wind energy systems. In fact, several turbine manufacturers such as Vestas and GE use the same basic design for their on-shore and off-shore models. The technological differences between off-shore and on-shore wind turbines are minor. The most significant differences, and the ones that present the greatest challenges, are operational in terms of turbine construction and turbine decommissioning.

The real differences are found in the project life-cycle - an off-shore wind turbine requires significantly different approaches at every stage of a project. Off-shore wind turbines do exhibit differences from their land-based counterparts, such as applicable design standards, component redundancy, and automation features.

In 2006, the International Electrotechnical Commission's design standard IEC 61400-3 was published for off-shore wind turbines. All major wind turbine manufacturers now design to this IEC standard, which governs structural design and reliability. Off-shore wind turbines are designed for one in 100-year events whereas on-shore wind turbines are designed for one in 50-year weather extremes.

Off-shore wind turbines have design features that are different than terrestrial turbines.

These differences are:

- Size: Off-shore turbines tend to be larger. Off-shore turbines in the 5 to7.5 MW range are currently being developed.

- Access: Off-shore wind turbines require different methods of access for maintenance. Off-shore wind turbine tower bases usually have a landing for boat access and may have a helipad for helicopter access.

- Towers: Towers are designed for hydrodynamic loading from waves and currents. Freshwater and low-salinity environments also require the ability to shed ice.

- Condition monitoring: Off-shore wind turbines may employ Condition Monitoring Systems (CMS) to identify electrical and mechanical problems before component failure.

This allows the turbine to be serviced when weather conditions permit, thereby decreasing unplanned outages and increasing availability. A CMS will continuously observe and report on the blades, gearbox, and generator.

- Redundancy: Off-shore wind turbines may have redundant critical systems such as lubricating oil and cooling to provide higher reliability.

- Transformer Location: Many off-shore wind turbines have the generator step-up transformer located in the nacelle, rather than outside of and adjacent to the tower.

- Maintenance Crew Support: Off-shore wind turbines may include a space for maintenance crews to take shelter if they are stranded due to changing weather conditions.

- Tower Height: Off-shore wind turbines have historically been installed on shorter towers (60 meters), as compared to terrestrial turbines.

- Corrosion Prevention: Off-shore wind turbines may rely on dehumidification systems and cathodic protection to minimize the adverse effects of continuous exposure to moisture, though this may be less of a concern in the Great Lakes than in salty ocean locations.

Most aspects of turbine construction are different for off-shore installations. The specifics will depend on water depth and lake floor topography and geological conditions.

No off-shore wind energy project has yet been decommissioned. An unresolved policy question is whether to completely remove the tower foundation or only a portion of the structure when decommissioning.

3.2.2 Existing Off-shore Turbine Suppliers

Several wind turbines manufacturers currently offer products designed for off-shore use. The following table lists some of these turbines.

Table 3.3: Off-Shore Turbine Suppliers

Manufacturer	Turbine	Capacity (MW)	Rotor Diameter (Meters)
Bard		5	122
Dewind	D8.2	2	80
Enercon	Development	4.5	112
General Electric	3.6s	3.6	111
Multibrid	M5000	5	116
Nordex	N90	2.5	90
REPower	5M	5	126
ScanWind	SW-110-3500 DL	3.5	110
Siemens	SWT-3.6-107	3.6	107
Vestas	V90-3.0	3	90
WinWind	WWD-3	3	100

Recent trends indicate that off-shore turbines will get larger. For example, Enercon is developing a turbine in the 6 to 7.5 MW range, Repower is developing a turbine of about 6 MW and Clipper has deployed a 7.5 MW prototype with a 150 meter rotor on a 100 meter tower.

3.2.3 Adapting Wind Turbines to the Great Lakes

Wisconsin off-shore projects would likely have some savings as well as some extra costs compared to European off-shore projects. Currently, few European off-shore wind turbines are located in areas as cold as Wisconsin's Great Lakes. Likely adaptations to cold weather are:

- special coatings to prevent spray and rime ice adherence to transition sections, towers, blades, and nacelles;
- modified foundations with ice-breaking collars or other ice-breaking devices for both turbine and non-turbine platforms such as off-shore substations;
- special vessels such as ice sleds for winter maintenance and ice breaker or tug assistance in extreme ice conditions.

While such adaptations increase costs, these costs will likely be modest in Lake Michigan because the ice climate there is not normally severe. In Lake Superior, ice adaptation costs are likely to be somewhat higher due to a more severe ice climate.

In some respects, Wisconsin off-shore projects would operate in a more favorable climate than their European counterparts, which are located in salt water, often in very stormy places (Irish and North Seas). Wisconsin off-shore turbines likely would not need:

- electrical transformers inside towers;
- special measures or air conditioning to prevent salt air from condensing inside nacelles and towers;
- anti-corrosion paints;
- long transition sections to allow for major storm surges, tides, and massive storm waves as Great Lakes water level variations are smaller, especially in Wisconsin waters.

3.2.4 Future Developments in Off-shore Technology

Future off-shore turbines are likely to be increasingly different from on-shore wind turbines. Current European off-shore wind turbines are similar to inland wind turbines. This is likely to change as off-shore developers and wind turbine manufacturers focus on optimizing turbines for off-shore use. Potential changes include:

- use of higher-tip-speed rotors which will be noisier but reduce torque on drive train components, allowing some nacelle and rotor weight reductions;
- use of one or two-bladed turbine rotors, enhancing weight reductions;
- increased use of lighter weight towers;
- increased use of permanent magnet or direct-drive generators;
- increased use of lighter-weight blades;
- increased use of new, lower-cost, foundation concepts in shallow waters;
- use of lighter-weight, lower-cost, concrete floats for moored turbines;
- increased use of self-diagnostic sensors and software to detect incipient electrical and mechanical problems;
- use of larger wind turbines, that reduce per site costs; and
- use of vertical axis wind turbines (VAWT)[24]

[24] This paper focuses on what are referred to as Horizontal Axis Wind Towers. Another type of wind turbine which is not discussed at length in this paper is the Vertical Axis Wind Turbine (VAWT). With a VAWT the axis of

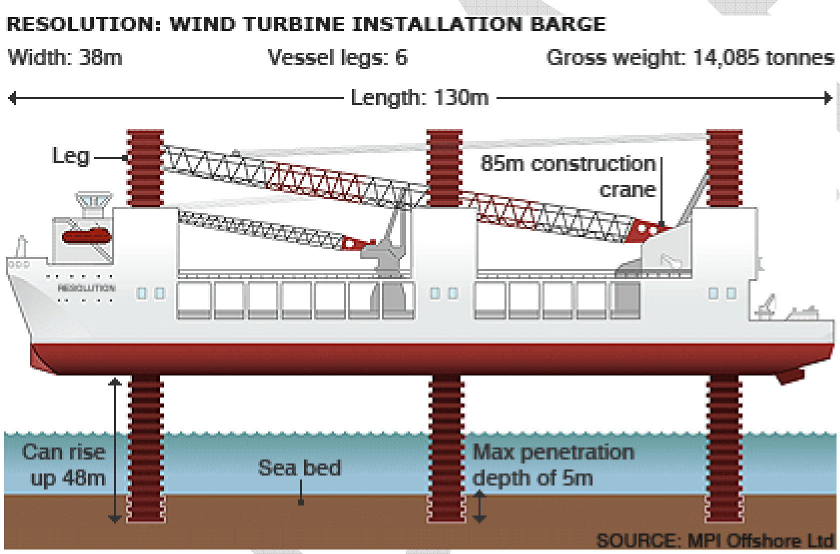
3.3 Construction Equipment/Techniques/Requirements

3.3.1 Equipment

All existing commercial off-shore wind energy projects have used similar barge-type vessels to install their projects. The most common vessel used for installation is known as a jack-up barge.

The jack-up barge has multiple legs that extend from the barge to the sea/lake bed when moved in place for foundation or wind turbine installation. The legs have the ability to push the barge above the water which provides a static and safer working platform and also enables the installation crane to have a shorter boom length. The working platform can be from 80 to 225 feet above the bottom of the jack-up columns, which sink into the lake bottom. The barges need to have enough capacity to support the installation crane weight plus turbine component loads. For barge capacity reference, a land-based installation crane for a 1.5 to 2 MW wind turbine weighs around 500 tons.

Figure 3.4: Jack-Up Barge for Wind Turbine Installation



Source: MPI Off-Shore Limited, www.mpi-offshore.com

Currently there are no barges capable of constructing such projects in operation on the Great Lakes. Barges would need to be constructed on or brought to the Great Lakes. An issue that needs to be addressed when evaluating barges is limitations on the size of vessels entering into the Great Lakes. Barges accessing the Great Lakes via the St. Lawrence Seaway are limited in width and depth by the size of the locks. The maximum allowed vessel beam and draft would

rotation is perpendicular to the wind stream and the ground. A familiar, small scale VAWT is the three-cup anemometer, which is used to capture and measure wind speed. Another, larger scale example, is the Darrieus turbine, which is often visually compared to an egg beater. VAWTs are experiencing a resurgence of interest and experimentation by various manufacturers.

be 78 feet and 26 feet. The width would be the critical dimension concerning the jack-up barges since required barge widths for off-shore wind turbines range from 70 feet to 100 feet.

For vessels sourced from the southern hemisphere, Pacific Ocean or the gulf of Mexico, another path to Lake Michigan and Lake Superior may be through the Chicago Sanitary and Ship Canal. This canal is the only shipping link between the Great Lakes and Mississippi River systems. The maximum width and draft allowed through the canal is 110 feet and 9 feet, which would allow wider barges than the St. Lawrence Seaway.

Other equipment installation options for shallow wind energy projects are the converted turbine installation vessel (TIV), the purpose built TIV, and the Merlin System. For deeper installations the jack-up barge, the purpose built TIV, and the Merlin System can also be utilized, but other options are being evaluated that would use tug boats to pull the object from port to its operating location. These options include the Titan Wind Turbine Platform, Floating to Fixed Wind Energy Concept (F2F), Dutch Tri-floater, tension leg platform, WindSea, and Blue H Technology.[25]

There is currently one purpose-built wind turbine installation vessel, named the Mayflower, in the world. It is owned by Vroon, an international shipping company headquartered in the Netherlands. Vroon has ordered two additional purpose-built wind turbine installation vessels with large jack-up systems. These vessels are estimated to cost $225 million each and are expected to be available in 2011.

Similar vessels of this magnitude would need to be constructed within the Great Lakes or be built in pieces elsewhere and assembled at the Great Lakes. There are currently discussions that Trillium Power Energy Corporation may be interested in procuring a purpose-built wind turbine installation vessel for a proposed project in Lake Ontario.

[25] Merlin Off-shore Wind Installation System, The Engineering Business Ltd., Tim Bland

Table 3.4: Off-Shore Turbine Installation Vessels

Type of Vessel	Turbine Installation Capacity[1]	Comments
Self propelled or Jack-up crane barge	Varies from 2 MW to 2.5 MW	Vessels are in heavy demand for use on marine based civil construction projects (oil and gas industry, coastal structures, and waste outfalls). Crane capacity and leg length are limiting factors.
Converted turbine installation vessel (TIV)	Up to 2.5 MW	Jack-up leg length and crane lift capacity are limiting factors.
Purpose built TIV	Up to 5 MW	Expensive to construct, with planned construction period of 18 months. The only specialized vessel built to date took 24 to 26 months to construct and deliver.
Merlin System	Small to large wind turbines	Full turbine assembly on-shore (including tower mechanical completion activities) with installation performed off a floating barge that tilts fully assembled turbine into place. Has not been used on a commercial project to date.

3.3.2 Off-Shore Vessel Availability

Jack-up crane barges are the most commonly used off-shore wind project installation vehicles, but are in high demand in the oil industry in Brazil, Nigeria, the Gulf of Mexico and other locations due to increasing oil prices. As a result, costs for jack-up barges remain high and availability a critical item in scheduling an off-shore project. The estimated cost for a jack-up barge, with the capacity and size required for an off-shore wind project, ranges from $50,000 to $60,000 per day. Additionally, a large crane would be needed for placement of components. Comparable costs of cranes for land-based projects range from $13,000 to $19,000 per day.

Some deep water foundation options being evaluated may eliminate the need for jack-up barges, but these are in the development stage at this time. If testing of one or more these options proves to provide a more economical installation, this would eliminate the need for the jack-up barge. Tugboats, which would then be used as the primary vessel, are more readily available than barges.

3.3.3 On-Shore Assembly and Off-Shore Work

3.3.3.1 Lay-Down and Staging Area Requirements

An on-shore location, known as a lay-down area, is needed to store the wind turbine components prior to assembly and installation. Most wind turbine components are manufactured overseas, principally in Europe and Asia. Components are shipped in dedicated ships in large batches. For land-based wind turbines a ship may hold as many as 30 sets of blades, hubs and nacelles (150 large components). Once this ship reaches port it needs to be unloaded and the components stored. Tower sections are shipped separately. The components for thirty wind turbines need approximately eight acres for lay-down. Depending on the foundation method used, some assembly of foundation components at a port-side lay-down area could also occur.

In addition to the lay-down area for the components, space is also likely needed to pre-assemble some of the components. There are two typical techniques for staging and pre-assembling components. With one, the turbine blades are attached to the hub in a horizontal plane forming a three-bladed assembly. This blade assembly is then placed onto a barge for transport to the wind turbine site.

Another method of pre-assembly is the “Bunny Rabbit”. In this procedure, only two blades are attached to the turbine hub. Then the bladed assembly is turned vertical with the blades at the 2 o’clock and 10 o’clock position and the hub is mated to the nacelle. The “Bunny Rabbit” is then placed onto a barge for transport to the wind turbine site.

Both of these techniques save time at the site. They require additional space of between five to ten acres depending on how many assemblies are being performed at one time.

A typical lay-down and staging area would be 15-20 acres, at the port in close proximity to ship and barge facilities. Such facilities are available in Milwaukee, Green Bay, and Superior and may be available in other cities along the lake shore.

3.3.3.2 Safety

Weather is the single largest risk to safety in the construction of off-shore wind turbines. Weather conditions in the form of wind, waves and lightning pose threats to the construction equipment, the wind turbine equipment and the construction personnel.

The wind inhibits the ability to safely perform critical crane lifts - wind turbine components tend to move about in strong winds due to their large cross sections. Construction cranes with booms may need to have their capacity down-rated or operations curtailed depending on the wind conditions.

Waves pose a risk because assembling wind turbines requires lifting and mating of large, heavy fabrications. A lifting platform destabilized by high waves poses danger and exposure to damage for personnel and equipment. Lightning is an obvious hazard to personnel and equipment. While thunderstorms can occur at any time on the Great Lakes, they are most likely from May through September.

3.3.3.3 Construction Season, Operations Plan and Schedule

Weather-related safety issues are a primary limit on off-shore construction. The prime on-water construction season is during the months of June, July and August. Historically, this is the period with the fewest days where wind or wave levels would interfere with or prevent construction. Strong winds are infrequent during these months and are mostly associated with thunderstorms. The off-shore construction season also includes April and May, and September and October; however, in each instance the probability of gaining productive days diminishes as you move away from the prime construction season. Wind and wave levels diminish during April and May, and in September and October begin increasing again.

The marine contractor must respond to the weather. Cranes on floating barges are susceptible to waves. In shallow waters stakes (spuds) are driven into the lake bed to anchor the boat and reduce the rolling motion. In deeper waters anchor systems are employed. As a practical limit, floating equipment can be used only when wave heights are five feet or less.

Operations may need to cease and a move made to a harbor of refuge when waves are greater than five feet or when there is a thirty percent chance of waves greater than five feet. With an on-water transport rate of five to ten mph a move to safe harbor can take several hours, depending on how far off shore the work site is and the location of the nearest safe harbor. There can be and are "false alarms," with the construction crews heading for safe harbor when bad weather in the end does not materialize.

It is possible that some of these situations can be mitigated by the technology of the installation, such as the use of a jack-up barge (3.3.1), or the provision of on-site shelter, to avoid or lessen the necessity of returning to shore in a storm.

Uncertainty due to the effects of weather and the lack of experience with building in-lake structures on Lakes Michigan and Superior will make it difficult for a contractor to establish and commit to a construction schedule. With land-based wind turbines, after gaining experience, it is common to erect one turbine per day per crane. It is likely to take longer to erect an off-shore wind turbine, given the effects of weather.

3.3.4 Wind Turbine Decommissioning

Decommissioning a turbine requires equipment similar to what was used for the original installation. One of the key items in decommissioning will be to find or develop markets for certain materials. Currently, there are developed recycling streams for concrete, steel, aggregate and metals. The fiberglass blade is one major wind turbine component that does not have an established recycling market. This is an area that should be addressed in the next five to ten years as turbines installed in the 1980's are being decommissioned. The National Renewable Energy Laboratory has estimated project decommissioning costs at three percent of the total project cost, which would range between $90 and $150 per kW.

3.3.5 Off-Shore Wind Energy Project Costs

Currently, there are no off-shore wind energy projects in the United States or North America and no basis to predict capital costs for Wisconsin. However, there are a number of European off-shore wind energy projects to look to for cost examples. The majority of them are less than 100 MW in size, and in shallow saltwater where winter icing is of limited or no concern. These projects are not necessarily close analogs to future Wisconsin projects, but offer much of the insight we have into off-shore costs.

3.3.5.1 Off-Shore Wind Energy Project Capital Costs – European Experience

The first generation of European off-shore wind energy projects of at least 40 MW size were built between 2002 and 2006 and had installed costs of approximately twice the costs of on-shore wind projects installed the same years.[26]

Europeans are now installing what can be viewed as a second generation of off-shore projects. They are generally larger and benefit to some degree from lessons learned with earlier projects. Some of these projects are also in deeper waters than their predecessors, but they are still considered to be in shallow water. Looking at some of the projects built between 2007 and 2008 [27], it appears that these projects will mostly come in at final price tags of less than 200 percent of inland wind energy project installed per kilowatt (kW) costs. One project, Egmond aan Zee, was completed in April 2007 at a cost of $272 million for 90 MW or about $3,022 per kW. It is unclear when the dollars invested in the project were spent and whether these numbers represent "overnight" costs (the net present value of all the dollars invested), or the sum total of all the dollars invested, regardless of what year they were spent. Robust, definitive cost estimates have not been found for off-shore projects at this point in time.

While both on-shore and off-shore wind have been experiencing substantial inflation in installed costs in recent years, there is some evidence that the inflation is faster for on-shore projects. For instance, in a 2006 comparison of 2005 costs, David Milborrow, a UK wind consultant, stated that the average cost of installed on-shore wind was 1191 Euros per kW and that of off-shore was about 1800 Euros per kW[28]. A RISO[29] Report in 2007 termed off-shore wind "some 50 percent more expensive than on-shore wind."[30]

In some cases, it appears that installed capital costs of current off-shore projects are still as much as 200 percent of those of on-shore projects. In others, cost appears to be closer to 150 percent. BTM Consult APS, a Danish renewables consulting firm, reported inland installed costs rose 74 percent while off-shore installed costs rose 48 percent. Overall, it appears that the gap between the installed cost advantage of on-shore versus off-shore wind projects in Europe may be narrowing.

3.3.5.2 Wind Energy Project Cost Drivers

[26] David Milborrow, Wind Power Monthly (2006)
[27] Egmond aan Zee (NL-North Sea), Q7 (NL-North Sea), Lillgrund (SW-Baltic), Rhyl Flats (UK-Irish Sea), Solway Firth/Robin Rigg (UK-Irish Sea), and Horns Rev II (DK-North Sea)
[28] David Milborrow
[29] RISO DTU is the Danish National Laboratory for Sustainable Energy, housed at the Technical University of Denmark.
[30] J. Lemming, et al. (Riso 2007), "Off-shore Wind Power Experiences, Potential and Key Issues for Deployment," p. 3, www.iea.org/Textbase/work/2007/off-shore/background.pdf

Wind turbine prices have risen in the past few years, but not in a readily predictable fashion. Factors that have driven these price increases include:

- Currency Exchange Rates

  Turbines or their components that are supplied from overseas are subject to fluctuations in exchange rates. In the past few years, the exchange rates relative to the U.S. dollar have not been favorable and at the time of this report have been worsening. This effect may lessen as more factories are built in the United States and/or components are sourced from the U.S. or if factors affecting exchange rates change.

- Commodity Prices

  Wind turbine project prices are heavily dependent upon metal commodity prices. The prices of copper, steel and aluminum have increased well beyond the general inflation rate in recent years. Copper is used in the generators, tower wiring and collection system cable. Steel is used in the tower, foundation, and components in the nacelle. Aluminum is used in collection system cable.

  Wind turbines also require a significant amount of concrete. Concrete prices have risen faster than the general inflation rate.

- Wind Turbine Demand

  Demand for wind turbines has steadily increased in the United States. Backlogs of one year are common in the industry. Production facilities continue to be built but demand due to the adoption of RPS requirements by Wisconsin and more than 20 other states may continue to keep demand high for the years to come.

3.3.5.3 Cost Drivers in the Great Lakes

There are factors likely to change costs when comparing potential Great Lakes projects to European projects. Factors tending to increase installed costs for shallow water projects include colder winters, more icing, and greater average water depths than in Europe. Factors tending to decrease costs include a fresh water environment, smaller mean and maximum wave heights and less stringent corrosion resistance needs for submarine cables and turbine structures. Other additional cost drivers for off-shore wind projects that could come into play include the availability of construction equipment and experienced off-shore construction crews in the Great Lakes area, and the introduction of new technologies for items such as foundations, which would also have an impact on price.

For any water project in Lake Superior, the capital costs would likely be somewhat higher due to a more challenging ice climate. For deeper water projects, there is no comparable European off-shore wind project in existence or permitted to date. The deepest existing off-shore wind project is a two-turbine installation in about 44 meters of water at an off-shore oil platform site in the North Sea east of Scotland (Beatrice). Lake Michigan off-shore projects on the Mid-Lake Plateau or Two Rivers Ridge would likely involve sites of 60 to 80 meter depth, perhaps even deeper.

While installed costs cannot confidently be predicted for deep-water projects, they can be more confidently estimated for shallow-water projects. Based on the European experience, these are likely to be in the range of 140 to 200 percent of on-shore costs.[31] In deeper waters, the technology will drive costs. For example, while the Beatrice Site employs tetrapod foundations, Lake Michigan deep-water projects could involve floating, moored turbines, possibly using tension-leg platform or Dutch tri-floater technology. No one has yet deployed such technology with a commercial scale wind turbine, making installed costs uncertain.[32]

While the floating concepts have some appeal, there is considerable uncertainty as to their installed costs. While installation costs may be lower, grid connection costs will be higher than for shallow-water projects. Floats will likely cost more than shallow water pilings. On the other hand, the ability to use lighter weight turbines and lattice towers should drive costs down. A final advantage of the floating concepts is that they lend themselves to large, gigawatt-scale projects which could produce economies of scale, along with the potential economic advantage of manufacturing this 21st century technology in Wisconsin.

Capital cost premiums over on-shore may decline with time as technology improves. Deep-water wind technology could experience even larger percentage cost declines than shallow-water technology due to its lower degree of current maturity.

3.3.5.4 Off-Shore Wind Operations and Maintenance Methods

Off-shore wind turbine operation is similar to land-based wind project operations. However, there are some differences. With land based turbines, scheduled and emergency maintenance and repairs can be accomplished with personnel reaching the turbine installation by an access road using a truck or similar vehicle. If any sizeable equipment needs to be changed out, a crane can be mobilized. Although crane operation may be limited in high winds, the majority of necessary maintenance and repairs can be accomplished during inclement weather conditions.

With off-shore based turbines, weather conditions may limit both access and the ability to carry out scheduled and emergency maintenance and repairs. Support ships or helicopters are used to transport personnel and materials to the site. High winds, waves, ice or poor visibility may limit their use, especially during the winter. Maintenance or repairs may then be delayed. This could have the effect of reducing availability and net capacity factors. Because of these

[31] Robert Owen, a member of the Engineering/Economics Work Group, disagreed as to probable capital costs for initial shallow-water off-shore wind. He believes the likely cost range in 2012-2013 will be 140-170 percent of on-shore installed costs, with about 160 percent the most likely, and expects these costs to gradually decline relative to on-shore costs after 2013 as shallow water off-shore technology matures.

[32] British, Dutch, and U.S. groups (led by M.I.T.) have done some engineering on floating, moored, wind-turbine support systems. A company called Blue H has deployed a prototype floating, moored, wind turbine of modest size (80 kW) in the Mediterranean Sea in the last year and has proposed a 420-MW wind project using such technology with commercial-scale turbines south of Massachusetts.

issues, it is important to accurately predict when maintenance is needed and to perform preventive maintenance when weather permits.

Improvements in advanced monitoring and control systems (CMS) may mitigate some of these concerns. In the future more diagnostics of the performance of the turbine will likely be done remotely. In addition, turbine manufacturers are striving to lengthen the maintenance interval to once a year instead of the current semi-annual schedule. Off-shore wind energy projects may need to monitor conditions such as wave height and water temperatures and use this data to adjust operations.

Efforts to improve off-shore access focus on boat access methods emphasizing motion compensation or removal of the vessel from the water at a turbine location. For larger wind energy projects, using small purpose built jack-up vessels with integral craneage is also a possibility. For some off-shore wind turbines, craneage facilities within the nacelle are capable of lifting some of the heaviest components of the turbine. However, access using small purpose built landing craft continues to present the most pragmatic and economic solution.

3.3.5.5 Off-Shore Wind Operation and Maintenance Costs

According to several published research papers, operations and maintenance (O&M) costs for off-shore wind turbine installations are higher than comparable land based installations.

Recent estimates range from 125 to 250 percent of on-shore wind operations and maintenance costs.[33] This is due to several factors. On-shore equipment can be sourced and mobilized within a short period of time, usually within hours, and be available on site within a day. Off-shore lifting cranes are uncommon and may have to travel a considerable distance to an off-shore wind project site. The availability of specially trained personnel to service the turbines will impact costs, as will the additional time spent getting to and from the site and the special safety precautions required on the Great Lakes. Another component in the increased cost is the increased insurance costs of off-shore turbines.

These increased costs may be offset by economies of scale in both turbine sizes and also in the increased production of off-shore wind sites. In a 2006 report on operating costs of on-shore and off-shore wind projects, UK wind consultant David Milborrow concluded that off-shore operations and maintenance cost per megawatt-hour (MWh) are not substantially higher than those for on-shore wind, probably due to the fact that off-shore wind projects tend to be larger and can therefore benefit from economies of scale. Wind speeds also tend to be higher, which means the fixed costs are spread over a greater number of electricity units.[34]

[33] Robert Owen, a member of the Engineering/Economic Work Group, disagreed as to probable operation and maintenance costs for off-shore wind energy projects. He thought the likely O&M cost range in 2012-2013 will be about 120-150 percent of the on-shore costs per MWh, with about 135 percent most likely initially and expects these costs to gradually decline after 2013 as off-shore experience increases and condition monitoring technology improves.

[34] D. Milborrow (2006), "Operation and Maintenance Costs Compared and Revealed," Wind Stats 19, No. 3, p. 3.

In Lake Superior, it is estimated that the operations and maintenance cost premium for ice will be higher and that there would also be a cost premium for smaller wind projects in the Wisconsin waters of Lake Superior compared to Lake Michigan.

There is reason for optimism about off-shore Great Lakes operations and maintenance costs considering the efforts in Europe to reduce these. For example, a Dutch group has been working to adapt flight simulator technology to provide a stable platform at the bow of the vessel in two-meter (seven feet) waves.[35] This Ampelmann Platform may be deployed commercially by 2010.

As condition monitoring systems improve wind turbine maintenance issues will be dealt with as scheduled maintenance items in good weather before they force turbine outages in bad weather. Reductions in off-shore operation and maintenance costs may result from:

- Improvement of access methods for unscheduled and scheduled maintenance
- Development of access methods less sensitive to wind/wave conditions
- Reduction in time required for off-shore working
- Reduction in overall number of components and simplification of design
- Modular design approaches that facilitate the interchange of faulty modules
- Use of high reliability integrated components
- Placing electrical units in an environmentally controlled section of the turbine
- Development of effective conditioning monitoring and remote control systems

3.3.5.6 Example of Great Lakes Off-shore Development Costs

This section presents two hypothetical projects to illustrate potential energy costs from off-shore projects. The cost estimates begin with 2007 costs for on-shore wind generators. The Team did not make an attempt to forecast costs due to the uncertainty of future commodity and wind manufacturing costs. The results are highly dependent upon the assumptions utilized and significantly different outcomes could occur as actual costs and performance are better understood. Some Engineering and Economics Work Group participants have suggested that these calculations should not be presented because the unknowns are substantial. The major cost uncertainty is how wind turbine costs and pricing will escalate due to commodity pricing, exchange rates and turbine demand. The second major uncertainty is the cost of off-shore installation in the Great Lakes due to lack of experience, particularly for deep water projects, and access to the specialized equipment required for off-shore wind turbine development. As off-shore projects in other states are developed and experience grows these uncertainties will likely

[35] *See* www.ampelmann.nl/index.php?id=28

decrease. The two scenarios presented include a shallow water (less than 30 meters or 95 feet) and a deep water application. The shallow water scenario represents a project using technology that is currently being used in Europe and therefore could be installed today. The deep water scenario represents a project that would require a foundation that currently has not been installed at the depths being considered for the Great Lakes. A larger project is chosen for the deep water scenario to take advantage of economies of scale that may be needed.

3.3.5.6.1 Shallow Water Scenario

This scenario includes a 200 MW project located about five miles off-shore from a major load center using five megawatt wind turbines in shallow water. This site would cover approximately 11 square miles. It represents a project that could be developed using currently implemented shallow water foundation technology such as a monopile. By being located five miles from shore, the project would take advantage of increased wind speeds by being away from the slowing effects of land. Interconnection is assumed to be by one or more 138kV submarine cables from an off-shore substation to an existing on-shore substation. On-shore transmission upgrades are assumed to be minimal due to existing infrastructure that serves the load center. It is assumed that basic transmission interconnections are included in the total although this was not clear from the information used to establish the on-shore / off-shore cost differentials. The collection system between turbines would likely be a 35kV submarine system. This scenario assumes a vessel capable of installing the turbines and foundations is available in the Great Lakes.

Cost of energy (real levelized) is calculated assuming 50 percent debt / 50 percent equity financing and private development.

Assumptions

Installed Cost:	140 to 200 percent of on-shore costs[36]
2007 On-Shore Average Costs:	$2,000/kW[37]
Installed Cost (2007$):	$2,800 to $4,000/kW
Total Installed Cost:	$560 to $800 million
O&M Cost:	125 to 250 percent on-shore costs
2007 Average O&M Costs:	$0.01/kWh[38]
O&M Cost (2007$):	$0.0125 - $0.02/kWh
Discount Rate:	8.5 percent
Rate of Return:	11.0 percent (Utility rate of return)
Lifetime:	25 years
Capacity Factor:	35 percent net of losses
Cost of Energy Range (Calculation):	$0.112 - $0.169/kWh

3.3.5.6.2 Deep Water Scenario

This scenario includes a 1000 MW project located about 20 miles off-shore using 5 MW wind turbines in a water depth of 70 meters (231 feet). This site would cover approximately 56 square miles. It represents a project that would use deep water foundation technology that is currently being developed or is in conceptual design. By being located 20 miles from shore, wind speeds would be further increased over the shallow water scenario by being further away from the slowing effects of land. The interconnection is assumed to be two 345kV submarine cables to two on-shore substations and that the collector system is a 35kV submarine system. It is assumed that the costs of the transmission interconnections are included in the total, although this was not clear from the information used to establish the on-shore / off-shore cost differentials. Significant transmission system upgrades may be needed to integrate this project and these costs have not been included. This scenario assumes a water craft for setting the turbines and foundations is available in the Great Lakes.

[36] Robert Owen, a member of the Engineering/Economics Work Group, disagreed as to probable capital costs for initial shallow-water off-shore wind. He believes the likely cost range in 2012-2013 will be 140 to 170 percent of on-shore installed costs, with about 160 percent the most likely, and expects these costs to gradually decline relative to on-shore costs after 2013 as shallow water off-shore technology matures.

[37] Based on U.S. Department of Energy – Energy Efficiency and Renewable Energy's Annual Report on U.S. Wind Power Installation, Cost and Performance Trends: 2007

[38] Based on U.S. Department of Energy – Energy Efficiency and Renewable Energy's Annual Report on U.S. Wind Power Installation, Cost and Performance Trends: 2007

Assumptions

Installed Cost:	185 to 300 percent[39] on-shore costs[40]
2007 On-Shore Average Costs:	$2,000/kW
Installed Cost (2007$):	$3,700 to $6,000/kW
Total Installed Cost:	$3.7 to $6 billion
O&M Cost:	125 to 250 percent of on-shore costs
2007 Average O&M costs:	$0.01/kWh[41]
O&M Cost(2007$):	$.0125 to $.025/kWh[42]
Discount Rate:	8.5 percent
Rate of Return:	11.0 percent (utility rate of return)
Lifetime:	25 years
Capacity Factor:	40 percent net of losses
Cost of Energy Range (Calculation):	$0.126 to $0.211/kWh

Table 3.5: Summary Table of Energy Cost ($/KWh) for Two Hypothetical Scenarios

	Energy Cost ($/kWh)			
	Shallow Water Scenario		Deep Water Scenario	
O&M ($/kWh)	**$560M**	**$800M**	**$3.7B**	**$6.0B**
$0.0125	$0.112	$0.152	$0.126	$0.195
$0.0250	$0.128	$0.169	$0.143	$0.211

To the extent that capacity factors continue to improve with off-shore wind project experience, the cost/kWh will be reduced.

3.4 Constructability/Meteorological Issues

3.4.1 Wind Resources - Lakes Michigan and Superior

Four recent studies analyzed Great Lakes wind resources. AWS Truewind, a provider of renewable energy consulting services, addressed off-shore winds as part of its 2003 Michigan

[39] Estimate based on deep water costs being higher than shallow water costs and could be potentially significantly higher.
[40] Robert Owen, a member of the Engineering/Economics Work Group, disagreed as to probable capital costs for deeper water off-shore wind development. He believes the likely cost range in 2012 to 2013 will be 160 to 200 percent of on-shore installed costs, with about 185 percent most likely and expects these costs to substantially decline relative to on-shore costs after 2013 as deep water technology, now brand new, improves.
[41] Based on U.S. Department of Energy – Energy Efficiency and Renewable Energy's Annual Report on U.S. Wind Power Installation, Cost and Performance Trends: 2007
[42] Robert Owen, a member of the Engineering/Economic Work Group, disagreed as to probable operation and maintenance costs for off-shore wind energy projects. He thought the likely operation and maintenance cost range in 2012 to 2013 will be about 120 to 150 percent of the on-shore costs per MWh, with about 135 percent most likely initially and expects these costs to gradually decline after 2013 as off-shore experience increases and condition monitoring technology improves.

and 2006 Wisconsin Wind Map Studies.[43] Superior Safety and Environmental Services, Inc. (SSE) addressed Lake Michigan winds adjacent to southeast Wisconsin in 2004.[44] More recently, AWS Truewind released a new wind map for the entire Great Lakes Region.[45]

The most recent AWS Truewind map shows less robust wind regimes close to Lake Michigan's shoreline along the Wisconsin shore than the three earlier studies. Even with the less robust wind regimes being shown, off-shore wind for the vast majority of Lake Michigan waters is rated as Class 4 and 5, compared to the best on-shore winds in Wisconsin which are Class 3.

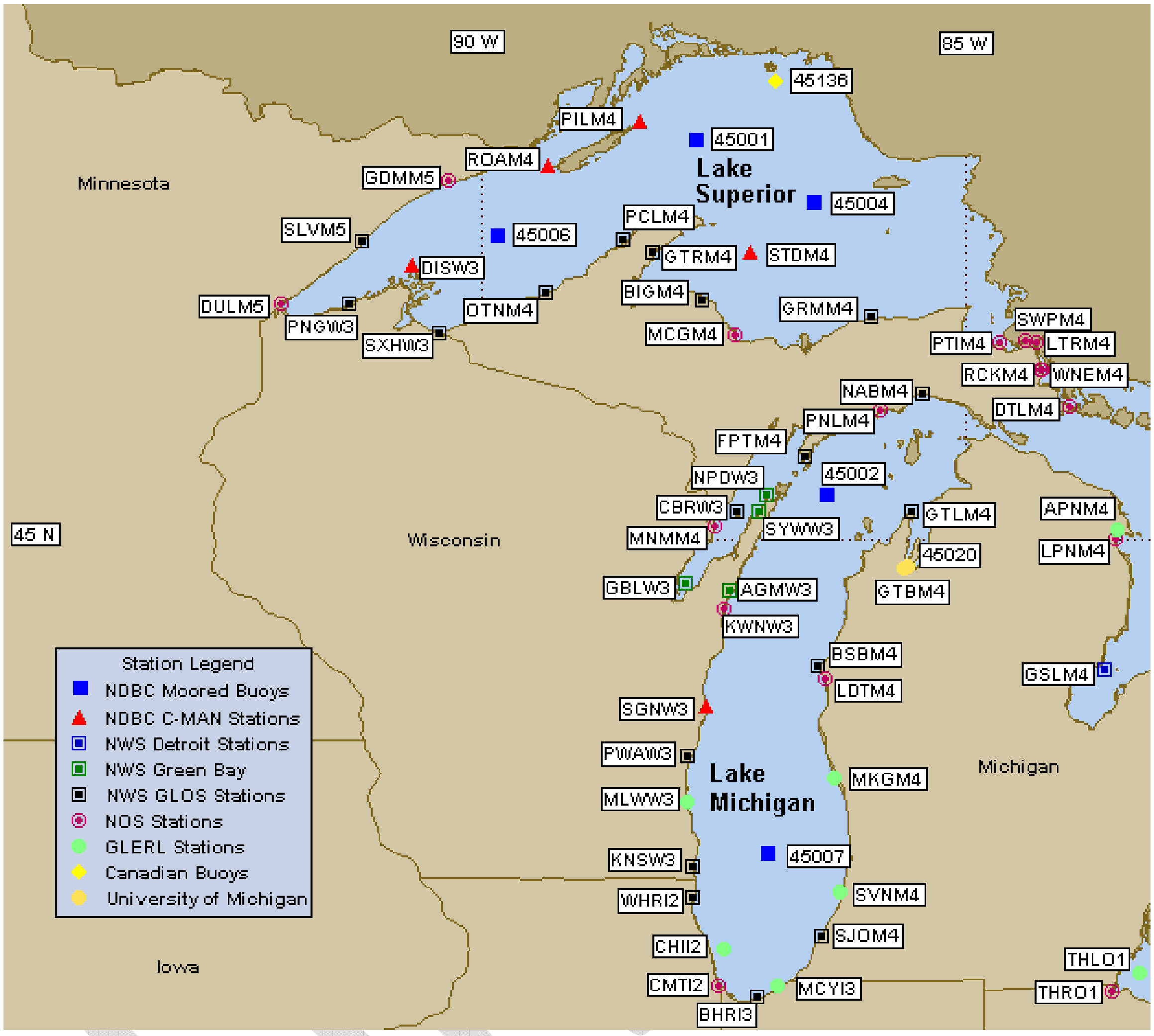
Raw wind speed data is available from two mid-lake buoys in Lake Michigan (buoys 45002 and 45007) and four mid-lake buoys in Lake Superior (buoys 45001, 45004, 45006 and 45136). The buoys are typically brought in during the winter. Below is a map identifying weather buoys operated by the National Data Buoy Center, a division of National Oceanic and Atmospheric Administration.

[43] The 2003 Michigan Study is not currently available and is apparently in the process of revision. The 2006 Wisconsin Study is available at the Wisconsin Focus on Energy Website in the form of maps which can be downloaded. http://www.focusonenergy.com/Information-Center/Renewables/Wind-Maps-Data/

[44] The SSE Study is available at the Wisconsin Focus on Energy Wind Map Page. http://www.focusonenergy.com/files/Document_Management_System/Renewables/lakemichigan_windresourcefinalreport.pdf

[45] The AWS Truewind Great Lakes Study, completed May 2008, is available on its website at: http://www.awstruewind.com/maps/offshore.cfm. This study was financed by NREL, several Great Lakes states, and the Province of Ontario.

Figure 3.5: Great Lakes Area Weather Buoy Sites



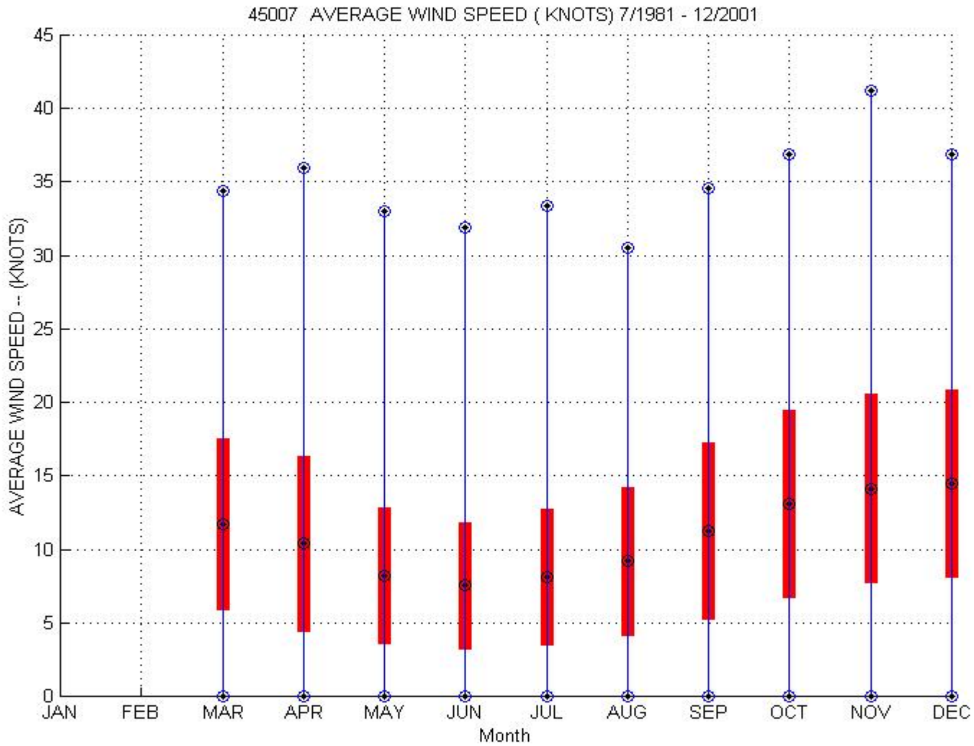
Source: National Oceanic and Atmospheric Administration (NOAA), National Data Buoy Center

Given that there are only two buoys located mid-lake in Lake Michigan, there is a relatively high level of uncertainty as to the available off-shore wind resources. This uncertainty could be minimized in the future by obtaining off-shore wind measurements closer to potential wind development areas. UW-Milwaukee Professor Paul Roebber, a meteorologist, is leading an effort to put a sodar on the Racine Reef Lighthouse to address some of the off-shore wind resource information gaps. Measurements off-shore using sodar or lidar would be particularly useful.

The buoys do provide information over a long period of time. Below are plots of average wind speed information for a twenty year period for buoy 45007.[46]

[46] Source: National Weather Service National Data Buoy Center, western Great Lakes buoy information for buoy 45007. www.ndbc.noaa.gov

Figure 3.6: Average Wind Speed information for Weather Buoy 45007 – 1981 to 2001



Source: National Oceanic and Atmospheric Administration (NOAA), National Data Buoy Center

The range bars show wind speeds for approximately 68 percent of the observations, and the circles indicate the minimum and maximum wind speeds at the buoy. One knot translates into 0.51 meters/second = 1.9 kilometers per hour = 1.15 miles per hour. There are only two buoys in Lake Michigan, and they are in the middle of the lake rather than closer to shore where wind energy projects might be built. In addition they measure wind speeds at heights much lower than wind turbines and wind speeds are higher at increased heights. Because of these factors, there is significant uncertainty as to Wisconsin's off-shore wind resources. In this report, the uncertainty is dealt with by using a range of assumed mean wind speeds for each site area at a typical wind turbine height of 90 meters. That range is set forth in the following table.

Table 3.6: Wisconsin Off-Shore Wind Resources (m/s Or [Mph])

Generic Lake Michigan Sites at 90 m Hub Height[47, 48]		
2 miles out[49]	5 miles out[50]	20 miles out[51]
7.3-8.0 [16.3-17.9]	7.7-8.5 [17.2-19.0]	8.2-9.0 [18.3-20.1]
Green Bay Site near 45º N, 87º 30' W at 90 m[52]		
7.4-7.8 [16.6-17.4]		
Lake Superior Site near 46º 45' N, 90º 25' W at 90 m[53]		
7.5-8.0 [16.8-17.9]		

Off-shore wind speeds would be higher than wind speeds at inland sites developed in Wisconsin to date. As a consequence of higher wind speeds, wind energy capacity factor, would generally be higher, particularly at the best off-shore wind sites, than at the best current on-shore sites. The assumed wind speeds above would result in a range of capacity factors from approximately 32 percent at the least windy sites to about 47 percent at the most windy sites. Capacity factors indicate the amount of energy that would be expected to be produced from a wind turbine each year. Each site would have a range of capacity factors, corresponding to a range of wind speeds.

Other estimates of capacity factors have higher ranges, particularly as experts predict technology improvements and larger turbines. Black and Veatch, as part of a report for 20 percent Wind Energy by 2030, estimates off-shore capacity factors ranging from 0.38 in 2005 to 0.48 in 2030.[54]

3.4.2 Water Depths

Lake Michigan is the third largest of the Great Lakes. It is 307 miles long and 118 miles at its widest point. From Milwaukee east to the Michigan shore it is approximately 81 miles wide; the width from Manitowoc, Wisconsin to Ludington, Michigan is approximately 58 miles. The average depth of the lake is 279 feet (85 meters), with the deepest point being 925 feet (282 meters). It has a water surface area of 22,350 square miles (57,800 square km.).[55] The water depths increase quickly as you move away from shore. The Michigan-Wisconsin state border is at the middle of the lake, equidistant from each state's respective coastline.

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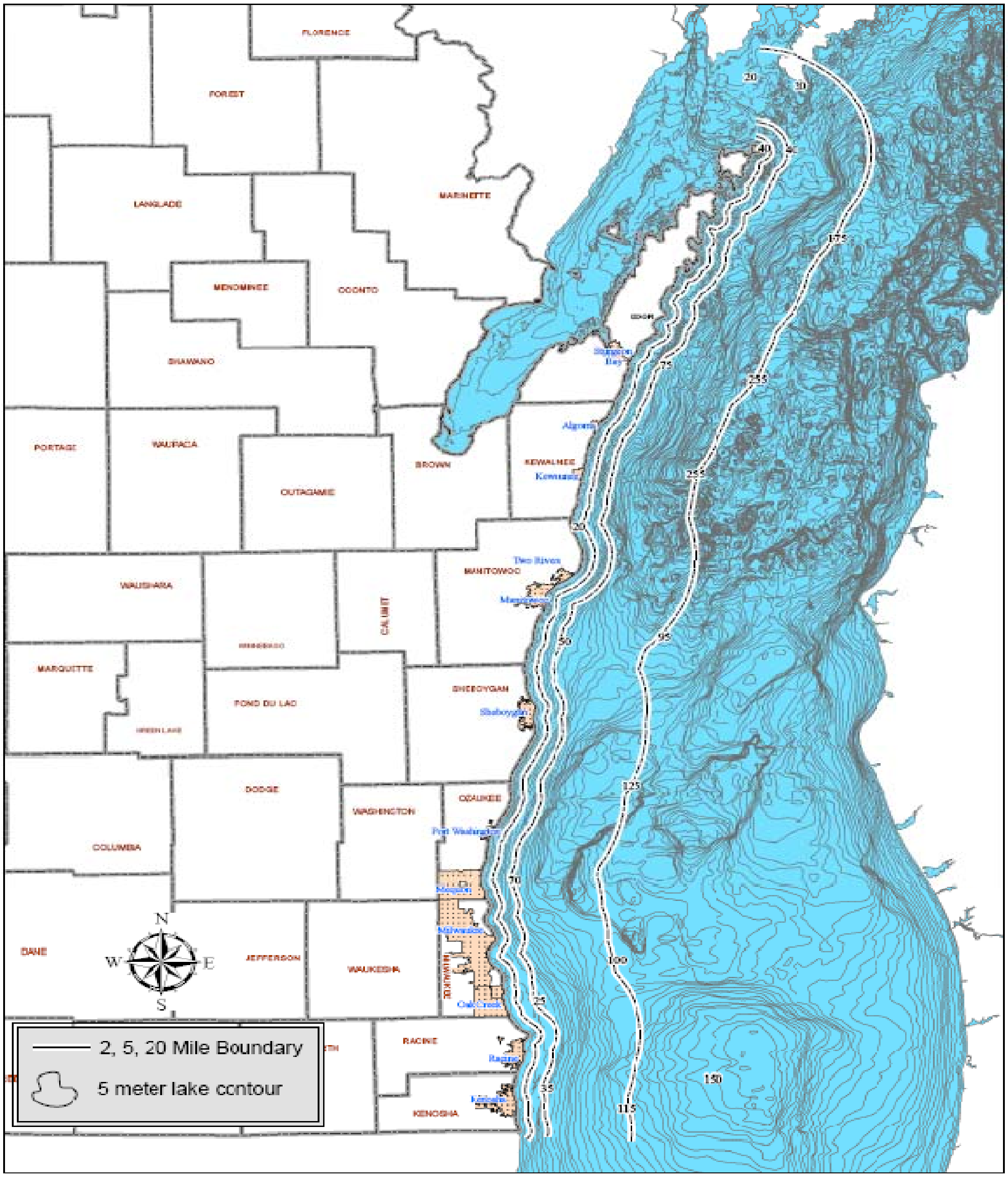
[47] This is the assumed hub height for a 5-MW turbine with a 125 m rotor diameter.
[48] The range of wind speeds given relates primarily to shallow sites South of Door County which are neither near points nor bays. Somewhat higher (about 0.2 m/s) wind speeds would apply to Door County sites and to sites near points, like Wind Point and the Sheboygan Area. Sites near bays would be about 0.2 m/s less windy.
[49] Assumed local vertical wind shear near 90 meters: .13
[50] Assumed local vertical wind shear near 90 meters: .12
[51] Assumed local vertical wind shear near 90 meters: .117
[52] Assumed local vertical wind shear near 90 meters: .13
[53] Assumed local vertical wind shear near 90 meters: .125
[54] 20 percent Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply, USDOE, http://www.20percentwind.org/20percent_wind_energy_report_05-11-08_wk.pdf
[55] Great Lakes Atlas, Environment Canada and U.S. Environmental Protection Agency, 1995

The Work Group looked at three generic sites in Lake Michigan, at distances from shore of two, five, and 20 miles. These distances were chosen to be representative of potential development sites, balancing distance from shore, wind energy potential, and water depths. Below is a map with these distances from the Wisconsin shoreline.

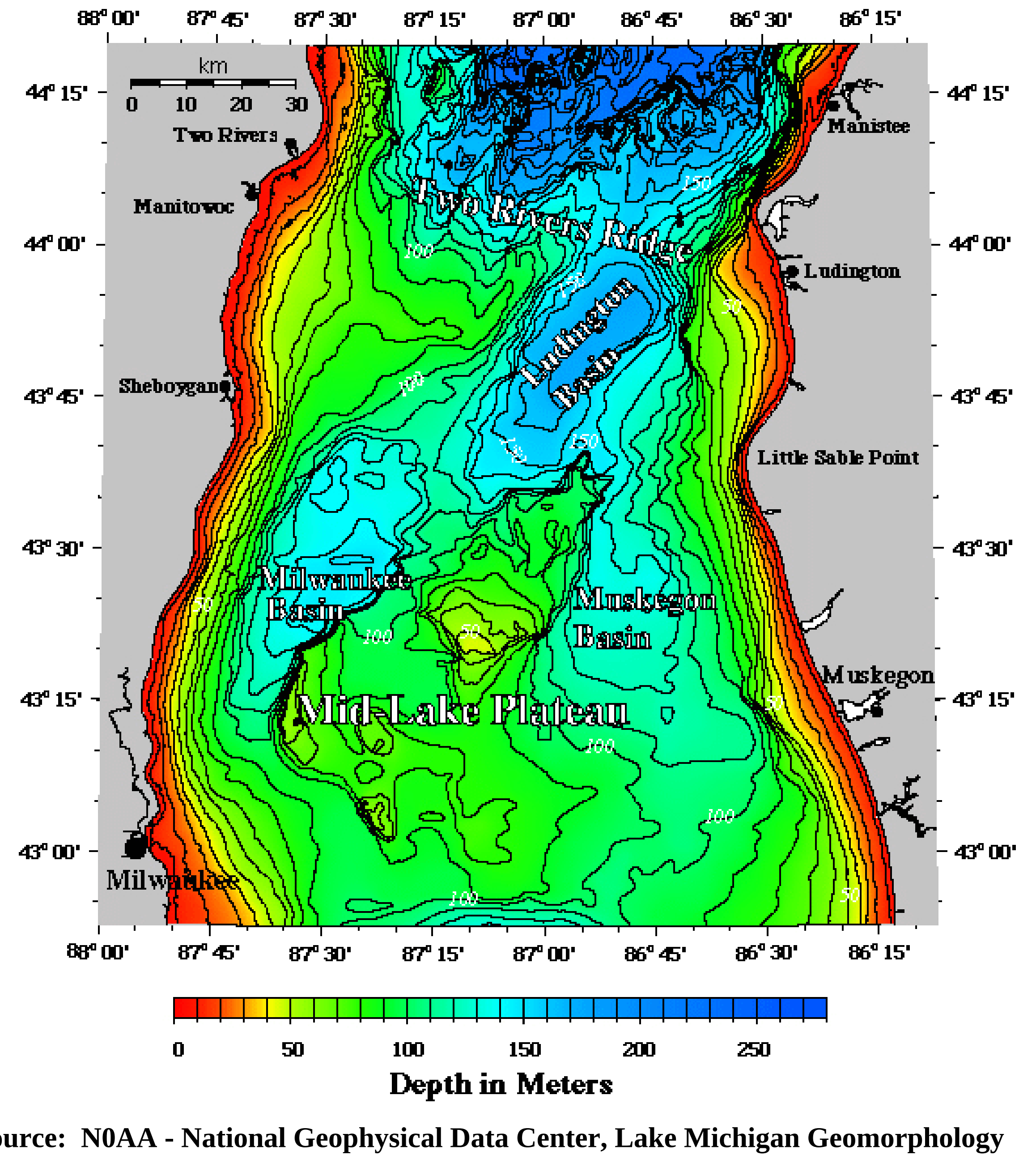
Figure 3.7: Map Showing Two, Five and 20 Miles From Lake Michigan Shoreline



Source: Public Service Commission of Wisconsin

The discussion at times references two features that are found in the lake: the Mid-Lake Plateau and the Two Rivers Ridge. These are reflected on the NOAA maps below:

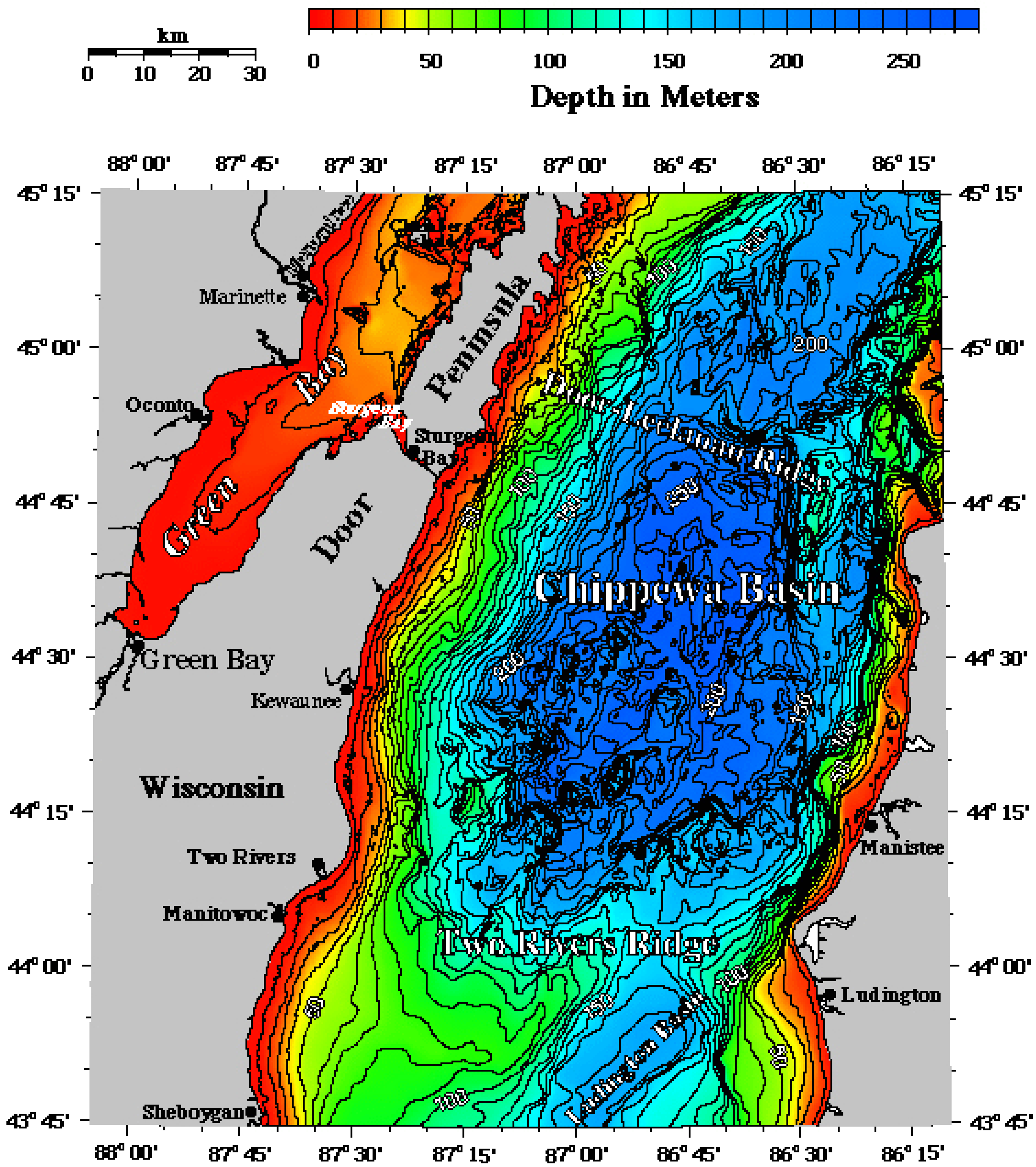
Figure 3.8: Bathymetric Map of Mid-Lake Plateau



Source: N0AA - National Geophysical Data Center, Lake Michigan Geomorphology

The Mid-Lake Plateau is a broad, relatively flat-topped ridge characterized by a steep incline on the Western side and a gentle slope on the east that lies directly east of Milwaukee. Much of it generally lies at depths of 80 to 90 meters, with some portions of it lying at depths of 40 to 60 meters.

Figure 3.9: Bathymetric Map Showing Two Rivers Ridge



Source: N0AA - National Geophysical Data Center, Lake Michigan Geomorphology

The Two Rivers Ridge lies east of Two Rivers and Manitowoc and extends east towards Ludington, Michigan. These two areas are noted because of the general rise in lake bed elevations that might offer sites that are farther off-shore yet with shallower water, with potentially better wind regimes.

Lake Superior is the largest of the Great Lakes in both surface area and volume. It is 350 miles long (563 km.), and 160 miles (257 km) at its widest. It has an average depth of 483 feet (147 meters) and a maximum depth of 1,332 feet (406 meters). It has a water surface area of

31,700 square miles (82,100 sq. km.). A bathymetric map for Lake Superior is not available from NOAA's National Geophysical Data Center.

3.4.3 Off-Shore Wind Project Space Requirements

Spacing for large off-shore wind turbine projects is typically larger than for on-shore development due to the array effects of multiple rows of turbines. For the proposed Cape Wind project turbine density is about 18 MW/sq mile. The following example is provided to get an idea of the space requirement relative to the Governor's Global Warming Task Force recommendations.

The Task Force recommended that 25 percent of the electricity used in 2025 come from renewable energy resources. It also proposed that ten percent of the State's electricity come from renewable resources located within Wisconsin. Wisconsin's 2006 electrical energy use was about 70,000,000 MWhs. If Wisconsin attained the energy efficiency and savings goals set out in the Governor's Task Force on Global Warming, the 2025 electric use would be about 85,000,000 MWhs. Ten percent of this usage is 8,500,000 MWhs.

Hypothetically, 2,550 MW of installed wind power capacity on Lakes Michigan and Superior operating at an average net capacity factor of 38 percent could provide all of the electricity needed to meet the in-state RPS goal proposed by the Task Force.

A more realistic scenario recognizes the existence of already approved in-state terrestrial wind projects and the more than 1,500,000 MWhs Wisconsin has historically produced from in-state hydroelectric power stations. If these assets are still operational in 2025, 1,800 MW of additional offshore wind capacity would be enough to meet the in-state RPS goal even if no other renewable resources are brought on line. If an 1,800 MW project similar to Cape Wind were constructed on Lake Michigan, the area required would be 100 square miles. Although this would be an extremely large project, it should be noted that the total surface area of Lake Michigan is 22,350 square miles. The hypothetical project would affect less than half of a percent of the lake's surface.

3.4.4 Ice Cover

Wisconsin's Great Lakes sometimes develop an ice cover, especially in late winter. Lake Superior is more prone to ice cover, and the ice cover develops in deeper water in Lake Superior than in Lake Michigan. In the Wisconsin portions of Lake Superior, ice cover occurs almost everywhere almost every winter. On Chequamegon Bay near Ashland, ice cover typically lasts about four months.

Lake Michigan has a less intense, but more variable, ice climate in Wisconsin waters. At one extreme is Green Bay, which has substantial ice even in mild winters. The ice in Southern Green Bay is often nearly as thick as that in Chequamegon Bay, and the entire bay is covered by ice for three months in a typical winter. Lake Michigan typically displays considerably less ice, outside of Green Bay.

The typical pattern outside of Green Bay in the Wisconsin waters of Lake Michigan has been for a narrow layer of thin ice to develop along most of the Western shore-line from Kenosha North to Washington Island in February in an average winter. Just 15 miles east atop the Mid-Lake Plateau east of Milwaukee or the Two Rivers Ridge east of Cleveland in southern Manitowoc County, ice typically does not develop or persist in a normal winter. The ice along the western shore from Kewaunee County to Kenosha County typically has persisted only about a month, rarely appearing before January or persisting far into March. It seldom approaches 100 percent coverage. It forms in the shallows and tends to melt when it drifts with the wind into deeper waters a few miles to the east.[56]

3.5 Transmission/Interconnection of Wind

3.5.1 Collector System

Typically, a distribution voltage collector system is used to gather the electrical power from a wind energy project. The turbine voltage is stepped up to distribution voltage with a transformer located at each turbine. Often, this voltage will be 24.9-kV, 33.0-kV or 34.5-kV or a similar voltage. Multiple turbines are connected together in a string with underwater distribution cable, and multiple strings meet at the collector substation.

Here, the voltage is stepped up from the distribution voltage used on the collection system to an appropriate transmission voltage. The transmission voltage depends on the capacity of the wind energy project, the distance between the collector substation and the termination on-shore, the voltages of the transmission system on-shore and other considerations.

The cables connecting the turbines and the collector substation may be buried in the lake bed or laid on the lake bottom. The burial methods will be very similar to that for burying underwater transmission.

3.5.2 Off-Shore Substation

Large off-shore wind projects may require one or more off-shore substations. The substation steps the voltage of the wind energy project collector system up to a transmission-level voltage for transmission to the existing grid on-shore. The substation platform would be mounted on a foundation similar to the foundation used for the wind turbines. Mounted on the platform are three key components: the distribution-voltage substation, the step-up transformer, and the transmission-voltage substation.

The distribution voltage feeders are gathered on a collector bus. The collector bus equipment would be similar in design to equipment used in land-based installations in space constrained locations. This equipment may be insulated with sulfur hexafluoride (SF_6). While the SF_6 gas is acknowledged to be a greenhouse gas, it is contained within the substation

[56] In early 2008, Wisconsin experienced a historically typical (from a degree-day standpoint) winter and typical lake icing, but the minimum water temperature on the Mid-Lake Plateau was about 35 degrees.

equipment. This technology is mature in land-based installations, and existing operations and containment practices are expected to be adequate for an off-shore substation.

The substation transformer technology is also very similar to on-shore transformers. The most notable difference is that the connection between the transformer and the collector and transmission substations would be enclosed to guard against the environment. A typical 200 MVA[57] transformer may contain about 15,000 gallons of insulating oil, and a 500 MVA transformer may contain about 20,000 gallons of insulating oil.

The transmission voltage substation would also use gas insulated switchgear using SF_6 gas. This equipment connects the transformer to the transmission cable to shore. Like the distribution voltage equipment, the technology for this equipment is mature in on-shore installations and will translate to the off-shore platform in a similar form.

3.5.3 Interconnection Between Collector and Transmission Systems

Depending on the size of the wind project and the distance from shore, several medium voltage cables, one or more high voltage cables, or one or more extra high voltage cables could be used. The greater the output of the wind energy project and the further it is from shore, the more likely the use of high voltage or extra high voltage cable becomes.

A typical medium voltage (approximately 34.5-kV) cable can carry a maximum of about 50 MW. A larger plant could use several such cables to increase capacity, though this may become uneconomical. At distances longer than a few miles the electrical losses can become significant providing additional cause to use a higher voltage cable.

A single high voltage (100-kV to 200-kV) cable can reach a further distance from shore and carry more power (up to about 200 MW) than a single medium voltage cable. A single EHV cable could carry 500 MW or more a longer distance than the lower voltage cables. However, at longer lengths, the capacitive charging of the EHV cable can consume a significant portion of the transfer capability, reducing the available capacity for real power transmission. This can be compensated with shunt reactors, though the length between reactors can limit the distance an EHV cable can span.

Several cable technologies have been used for underwater transmission. Solid dielectric insulations such as cross linked polyethylene (XLPE) have been used in high voltage installations and have been used in some, albeit limited, EHV cables. At the EHV level, self-contained, fluid-filled (SCFF) cables have a longer history and are considered a mature technology. The SCFF cables contain a synthetic insulating fluid kept under a low pressure. Under normal operation this fluid is completely contained within the cable. If a leak should occur, the fluid biodegrades within 30 to 60 days, and environmental impacts are minimized.

Cables can be embedded into the lake bottom or laid directly on the lake bed. Consideration needs to be given to the lake traffic passing over the cable as well as ice

[57] MVA, mega volt-amps or millions of volt-amps, a measure of how much capacity the transformer has.

scouring[58]; steps can be taken to reduce the possibility of the cable being damaged. Pipe-type cables, being enclosed in a metal pipe, are less prone to damage than the solid dielectric cables. However, a solid dielectric cable can be armored in high risk areas. One practice to protect the line is to install four cables, each a distance apart. Three of the cables are energized and the fourth is used as a spare. The cables are installed far enough apart to minimize the possibility of a single event damaging more than one cable. Should an electrical fault occur, the spare cable can be used to restore service. Typical burial depth is about six to ten feet.

A jet plow is typically used to embed a cable in the lake bottom. The jet plow rolls on the bottom and fluidizes the lake bottom material in a narrow path, limiting the amount of material displaced. The jet plow can be towed by a ship with dynamic positioning capability or a barge using mooring anchors. This construction method is able to achieve a consistent burial depth in sand or clay bottoms.

Another burial method is to use water jetting to create a trench in the lake bottom. The cable is then laid in the trench before the bottom material is allowed to sink back into the trench. Water jetting is more capable of cutting through more difficult material (such as rocky bottoms) and has been used at deeper depths than the jet plow.

If cable protection is required in areas where burial is difficult, the cable could be covered with concrete mattresses or rock.

The transition between the submarine cable and the shore is expected to be accomplished with horizontal directional boring. Off-shore structures (such as coffer dams) would likely not be needed for this type of construction. The directional bore would install a conduit through which the power cable would later be pulled.

During construction of the underwater cable, one or more fiber optic communication cables will also be installed for communication between the wind energy project and on-shore facilities.

Maintenance of an underwater transmission cable can be performed by an unmanned submarine. This routine maintenance inspects the cable for visual abnormalities such as the cable shifting due to underwater currents or other interference that may jeopardize the cable integrity.

3.5.4 Wind Generation - Operational Experience

In Wisconsin, system operator experience with wind power generation is relatively new and limited. As of January 1, 2008, ATC had only 30 MWs of wind generation interconnected. However, by year’s end the total is expected to grow to 449 MWs.[59] There is another 1,000 MW proposed land-based wind in ATC’s footprint with requested in-service dates in 2009. The Midwest Independent Transmission System Operator (Midwest ISO or MISO) and other system operators have had few issues with wind powered generation, and system operators are learning

[58] Ice scouring occurs when lake ice is pushed against the lake bottom.
[59] See Appendix G for a list of wind power projects to be in service by year-end 2008.

to deal with the rapid loss of wind powered generation using demand response and quick start backup generation. This creates challenges for system operators but has not resulted in serious impacts on consumers. Wind integration studies and operating experience have consistently demonstrated that wind forecasting tools and geographic diversity of the wind resources are able to address concerns that operators have, although operation of the power system does change with increasing amounts of wind penetration. System operators are learning how these changes will affect their particular system as wind projects are added in increasing amounts to their system.

MISO is working on several near surface wind forecasting methods to provide system operators with the tools needed to integrate wind project output into day-ahead and hour-ahead forecasts. They are also evaluating the need for increasing the spinning and ready reserve amounts for wind power generation capacity versus other powered forms of generation due to the variable output nature of wind energy. The 2006 Minnesota Wind Integration Study found as the amount of wind generation was increased, the regulating capacity and load following capability of the system needed to increase.

Having a combination of off-shore and on-shore wind resources would provide more geographic diversity, especially with off-shore wind blowing more during the day. This would help alleviate some operating concerns, particularly if coupled with increased accuracy of wind forecasting. It would not eliminate the need for back-up generation, but the amount needed may be reduced.

3.5.5 Transmission Infrastructure Development

In the Midwest, transmission is built, owned and operated by transmission owners within a franchise territory. The transmission owners are responsible for maintaining the reliability of the system within that area. The transmission owners can be vertically integrated utilities, stand-alone transmission companies, municipal electric utilities or cooperatives. In Wisconsin, ATC and Xcel Energy are the primary owners of transmission facilities. Xcel owns most transmission facilities within its utility's service territory in western and northern Wisconsin. ATC owns most other transmission facilities throughout the rest of the state.

The Midwest Independent Transmission System Operator (Midwest ISO or MISO) serves a transmission region covering fourteen states and a province of Canada. Within that region MISO operates a regional market for electricity comprised of generation owners, transmission owners, and load-serving entities. MISO is charged with managing the transmission grid, providing access and working to minimize reliability risks. It does not own or build transmission facilities. There are other regional transmission organizations (RTOs) across the U.S.

To be effectively utilized any electrical generator must be connected to the load. What physical form this connection takes is dependent on the "electrical distance" between the generation and load (or the grid), the amount of power to be transferred and the diversity or centralization of the generation or load.

As part of this investigation ATC and Xcel reviewed, at a conceptual level, the existing transmission system's ability to support additional wind generation in Lakes Michigan and Superior. An additional review was made of publicly available generator interconnection studies that were done for projects proposed for eastern Wisconsin.

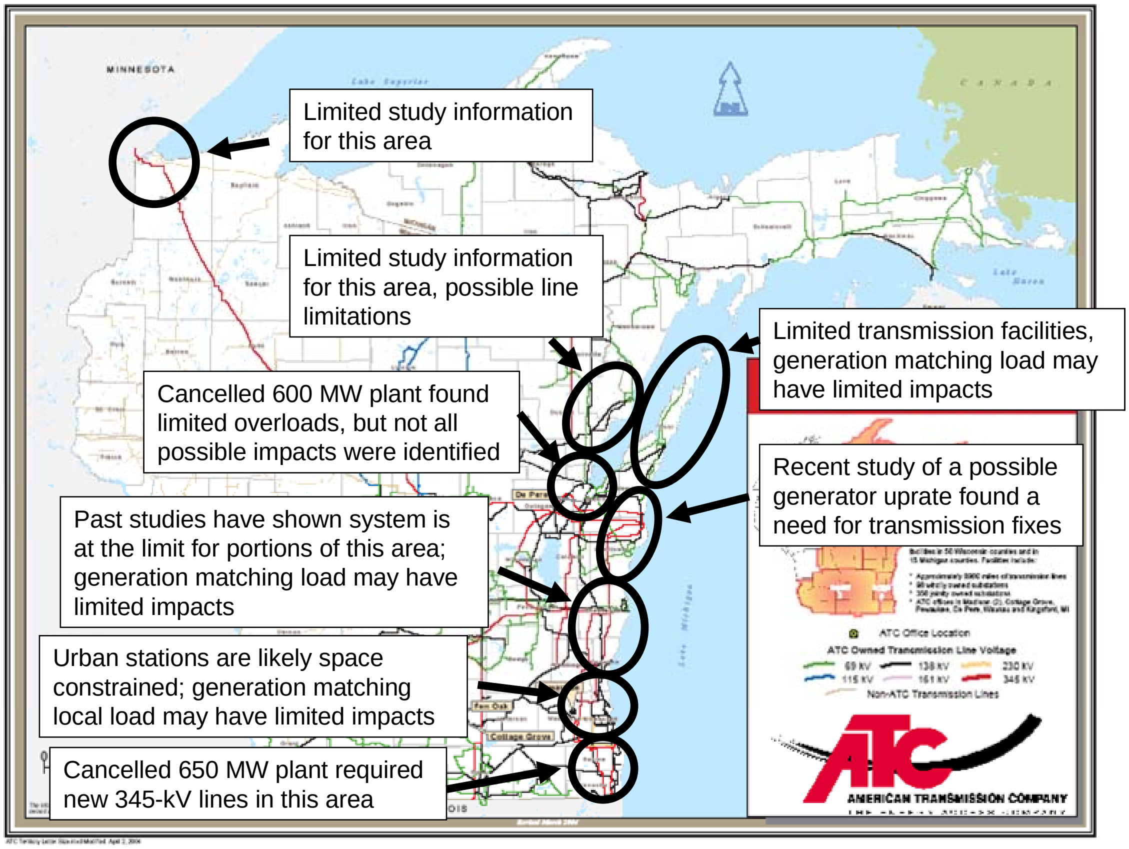
3.5.5.1 Lake Superior Shoreline

Much of the transmission near Wisconsin's Lake Superior shoreline is 34.5 kV because it is an area of the state that has lower load and historically slower growth. Currently, there are no utility-scale wind projects present in the Lake Superior area. One area that could support smaller-scale wind development is the 88 kV system in Ashland and Iron counties.

3.5.5.2 Lake Michigan Shoreline

The Lake Michigan shoreline from Door County to southern Wisconsin has a transmission system that is adequate for current reliability needs and could support some on-shore wind interconnections. Existing generation interconnection studies (see map below) indicate that there is little headroom for large-scale (1,000s of MW) wind developments without major upgrades to the transmission system. A large-scale wind development in Lake Michigan would likely require the addition of new transmission lines. For integration into the current transmission system, the best choice would be small-sized (100 MW) wind energy projects located off of existing significant load centers that could absorb the power being produced without having to transport it long distances. A more extensive county by county analysis is provided in the Appendix.

Figure 3.10: Existing Wisconsin Generation Interconnection Studies



Source: ATC

For larger scale off-shore wind developments, the Engineering and Economics Work Group discussed a larger backbone system running north-south along Lake Michigan either in Lake Michigan or on-land or a larger transmission line crossing Lake Michigan from east to west.

These lines could take different forms and may have additional benefits. Currently, wind developers in the MISO Generator Interconnection Queue[60] are developing sites in ATC's footprint predominantly along the Lake Michigan shore and along the Wisconsin-Illinois border. Building an extra high voltage line running north-south along the Lake Michigan shoreline on land could provide an outlet for both the on-shore and off-shore wind resources. Potential cable routes could be south toward Zion or Chicago or east toward Ludington or Muskegon, Michigan. Potential Wisconsin termini for underwater 345-kV lines include Point Beach, Edgewater, Port Washington (Cedarsauk), and Oak Creek-Elm Road Power Plants.

[60] Process used by MISO to study requests for generator interconnections to the transmission system. These studies analyze the impacts of proposed projects on the transmission system and identify any necessary upgrades or new construction that would be needed to accommodate the proposed interconnection.

Building such a line in advance of off-shore wind would likely have other system benefits, such as the ability to also support development of on-shore wind projects. Additional lines could also improve reliability - particularly in eastern Wisconsin - increase Wisconsin's ability to import less costly electricity, and reduce electrical system losses, lower costs and reduce emissions. One comparative benefit to underwater lines is that they will not impact as many landowners as on-shore transmission. However, there are additional challenges with constructing and maintaining underwater lines.

The transmission choices identified are to build overhead lines on-shore or to put underwater lines across the lake or running north-south in the lake or some combination of the above. The underwater lines under discussion include both Alternating Current (AC) and Direct Current (DC) lines. Overhead lines are well known in Wisconsin, have established routing and siting rules and regulations and have much more operational history. Current "need" determination by the PSCW relies on improvements to maintain the reliability of the system or to provide lower cost power for Wisconsin ratepayers. An expanded definition of "need" may be necessary to cover the strategic build-out of a transmission system to support wind development.

3.5.6 Regional Wind Transmission Studies

3.5.6.1 MISO Midwest Transmission Expansion Plan 2008 (MTEP 08)

MISO issues a Transmission Expansion Plan for its entire footprint each fall. It is developed by compiling the transmission plans of the transmission owners in its footprint. MISO then reviews each proposed project to ensure that it will provide the claimed benefits and that it does not harm any other portion of the transmission system.

Over the last few years, MISO has developed more of a top-down approach to transmission planning. MISO identifies the value of transmission across larger regions to capture the efficiencies available in the market. MISO is currently conducting several regional studies. These studies will produce a list of transmission projects MISO believes will provide value to the ratepayers of the MISO footprint. The results of these studies are also included in the MTEP each fall. It is important to note that MISO does not, however, build or own transmission and that the individual states have different levels of approval on the transmission that gets built.

3.5.6.2 MISO Regional Generator Outlet Study

Wisconsin, Minnesota, Iowa, Michigan, and Illinois have adopted Renewable Portfolio Standards, establishing goals or requirements for the percentage of energy within the respective states that should be provided by renewable energy at some point in the future. MISO has 60,000 MW of wind development requests pending in its generator interconnection request queue, and of these approximately 2,800 MW are for projects in Wisconsin. Each request is only studied after it has entered the MISO queue. This has led to a very lengthy time to complete the individual studies, necessitated re-study if a generator drops out of the queue and may have spurred the building of inefficient transmission system upgrades which would lead to higher overall costs.

In response to these issues, MISO is undertaking the Regional Generator Outlet study to develop a set of regionally coordinated transmission projects that over the next 5-15 years meet the individual state's renewable portfolio standard requirements. The study, due in spring 2009, will identify a delivery system that is technically sound and provides an equitable balance between the Midwest ISO generation interconnection queue, wind resources, geographic diversity, reliability and monetary costs. This study is being coordinated with other MISO planning studies including development of the Midwest Transmission Expansion Plan 2009. It is important to note that this study looks at requests already in the generator interconnection queue, thus its analysis does not include any off-shore wind projects.

The result of the study will be a conceptual overlay of transmission improvements that could support development and transmission of wind from western Minnesota and the Dakotas to Minnesota, Wisconsin and Iowa, in addition to producing and consuming wind more locally. Utilities, developers, transmission owners, and ultimately regulators and policy makers will weigh these options against the off-shore wind options as they decide how to meet renewable portfolio standards.

Transmission developed in conjunction with the different options will be paid for in different ways, depending on where in the MISO region the wind is and how cost sharing mechanisms, which are under discussion, evolve.

3.5.6.3 MISO Cost Sharing

Traditionally, vertically integrated utilities have built transmission to move the power from their generators to their customers ("load"). The transmission lines were paid for by the customers of that utility. Given a regional market and the need for a more robust transmission system, the industry recognized that there should be some cost sharing for larger transmission lines that provide regional benefits. The Midwest ISO has developed mechanisms to share the costs of some transmission lines across the entire footprint of MISO rather than across a single utility's customer.

MISO currently has two cost sharing mechanisms. The first is designed for projects built primarily to provide increased reliability on the transmission system. For very large transmission lines (345 kV and above), twenty percent of the total costs of the project is paid for by all ratepayers in the MISO footprint and the remaining 80 percent is shared by all ratepayers who receive some benefit from those transmission lines. The second cost sharing mechanism is designed primarily for transmission projects that are built to provide customers in one area of MISO access to lower-cost excess generation in other parts of MISO - "economic" projects. This mechanism has never been used, but would be specific to the project and reflect a cost-benefits analysis.

Cost sharing has two implications for off-shore wind projects:

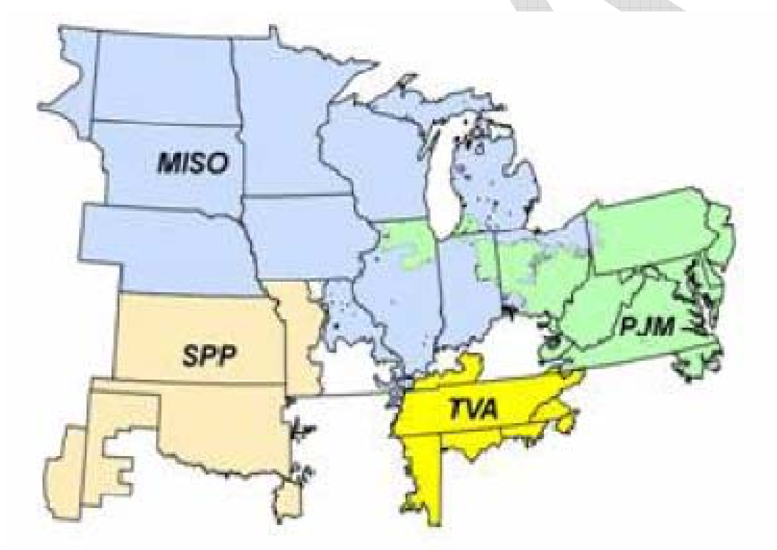
- If a larger transmission line were built in Wisconsin to provide transmission to interconnect wind projects and the transmission line also provided additional reliability or economic benefits to the MISO region, it might be eligible for cost sharing, reducing the costs to Wisconsin ratepayers.

- Given the Regional Generator Outlet Study described above, larger transmission lines may be proposed and built to move wind power from western Minnesota and the Dakotas, where on-shore wind regimes are better than Wisconsin on-shore wind. These project costs might also be cost-shared across the MISO footprint. Wisconsin ratepayers would then be paying some portion of those costs as well as the transmission costs for off-shore wind which could result in an inordinate amount of transmission costs being allocated to Wisconsin ratepayers.

3.5.6.4 Joint Coordinated Study Plan JCSP Study/Implementing DOE's "2020" Plan

The Midwest ISO has joined with four other regional transmission organizations (RTOs) to study the transmission that would be needed to provide 20 percent of the U.S. energy needs by renewables (mostly wind) by the year 2030. The four regions include MISO, the Pennsylvania-New Jersey-Maryland RTO (PJM), the Southwest Power Pool (SPP) and the Tennessee Valley Authority (TVA). The study region is shown below.

Figure 3.11: JCSP Study Region



Source: February 13, 2008, presentation "Cost Allocation of Transmission or Market Solutions" by Dale Osborne of MISO

This effort is focused on moving wind from wind-rich states in MISO (e.g. Iowa, Minnesota and the Dakotas) and the SPP region to the East Coast and to the Southeast area of the U.S. The implications for off-shore wind in Lakes Michigan and Superior are two-fold. One is the cost sharing. MISO and PJM are investigating joint cost sharing mechanisms that would apply across both their footprints. If implemented, Wisconsin ratepayers would pay a portion of the costs for both MISO and PJM projects. These "cross border" cost sharing mechanisms are not developed yet and would require stakeholder input and FERC approval before they could be implemented. The second implication is that, if the lines built are using alternating current (AC), Wisconsin would be able to use some of the available capacity from the lines built in Wisconsin for Wisconsin wind generators, either on-shore or off-shore. Another transmission system scenario includes the use of direct current DC lines. These could not be used by Wisconsin entities without very expensive DC/AC convertors to off-load power along the line. Current MISO studies do not include these inverters. How much transmission could be used would depend upon the size and location of the lines.

3.5.7 Summary

The development of off-shore wind on the Great Lakes is technically feasible, including addressing issues associated with ice. The wind resources on many parts of the Great Lakes are better than those found inland in Wisconsin. However, off-shore development would benefit from additional wind resource data for the lakes. Shallow-water near-shore sites are buildable now with existing technology and equipment. Wisconsin sites with the best wind regimes, however, are farther off-shore and in deeper waters. Their development depends on the continuing refinement of existing foundation and turbine technologies and innovations to meet the engineering challenges the deeper water poses.

Wisconsin's existing transmission system could support the development of smaller-scale off-shore wind power projects located near load centers. Development of larger scale projects would require upgrading the transmission system, possibly requiring the building of new lines. Developing a transmission line that parallels the Lake Michigan shoreline, either in the lake or on land, could support the development of off-shore wind and has the potential to better serve existing load centers. Wisconsin's transmission needs for wind must be viewed in the context of regional planning efforts that are looking at wind on a multi-state area, the adoption of Renewable Portfolio Standards by more and more states, and the interest in moving Great Plains wind to the northeastern United States.

Power from off-shore wind projects tends to be more expensive than power from on-shore wind projects. With the continuing development of off-shore wind power projects in Europe and potentially now in the United States, we should have access to better information regarding these cost differentials. This construction should also spur the development of improved construction techniques, procedures and equipment. These, combined with the higher energy production available from off-shore wind power projects, suggest that over time the cost differential between on-shore and off-shore wind projects should narrow.

4. COST AND FINANCING OF WIND ENERGY

4.1 Overview

It is generally accepted that the cost of building utility-scale off-shore wind projects will be higher than those for comparable on-shore projects. This could be a barrier to the development of off-shore wind. However, off-shore locations offer the possibility of access to better wind regimes and the potential that their greater energy output will offset at least partially the higher costs. This chapter offers a discussion of the financing of wind projects and approaches that could be used to lessen the financial hurdles to off-shore development.[61]

The operational virtues of off-shore wind over on-shore include higher capacity factors, better wind regimes in other wind metrics, and locational advantages with respect to being both further from residences and potentially closer to load centers. On the other hand, off-shore wind projects present challenges including significantly higher construction costs and difficult access for maintenance and operations.

Given the nascent status of off-shore wind, a few but growing set of installed units in Europe, no units deployed or under construction in either the Great Lakes or anywhere else in the United States, the estimates for both cost detriments and operational benefits are not well known.

The Engineering and Economics Work Group generated rough estimates of both increased costs and increased performance of off-shore wind compared to on-shore wind. These cost and performance estimates are used in this section as well as some additional information noted and documented where appropriate.

The PSCW can play a role in providing incentives for off-shore wind. These incentives could take the form of cost-sharing or grants, tax or credit-based incentives, or favorable regulatory treatment. Tax-based incentives include an investment tax credit, a production tax credit, and allowing accelerated depreciation, among other options. These incentives would impact the state's taxpayers rather than just a specific utility's ratepayers. Credit-based incentives include loan guarantees, securitized financing, direct loans and tax exempt financing among other options. Favorable regulatory treatment primarily includes ensuring cost recovery, providing additional profit on the project to offset the risk or allowing favorable accounting of renewable energy generated from off-shore wind projects compared to other forms of renewable generation.

In all of these incentive plans, the cost of the project is reduced by placing some portion of the financial risk onto ratepayers or taxpayers as the risk is shifted away from investors. This risk shift may lower the cost of the project to the owner but at the price of having some of the

[61] It is similar to analysis that was prepared for the WDNR/PSCW Integrated Gasification Combined-Cycle (IGCC) Technology report to the Governor. In Chapter seven of that report, financing incentives to reduce or eliminate the cost per MWh differential between the two technologies were discussed. This section very closely parallels that chapter.

risk and the associated potential project cost accepted by ratepayers or through society, by taxpayers.

This section discusses various financing incentives in some detail. However, it should be noted that the benefit of a particular incentive will vary by the type of electricity provider. Investor-owned utilities, independent and merchant power producers, and public power organizations will view incentives differently given their respective need for cheaper credit and their interest in tax offsets. For example, tax-based incentives will have no value for a public power agency, and loan guarantees may provide little incentive for investor-owned utilities since they already have access to low-cost debt. Independent power producers, however, may be very interested in both these incentives.

Of the incentives discussed in detail in the following sections, the option that appears to have the greatest impact on the final production cost of electricity from off-shore wind projects is securitized financing.[62] Securitized financing allows a utility to issue low-interest bonds that are backed by a dedicated revenue stream. Essentially, securitization pledges a utility asset (*e.g.* a dedicated revenue source from ratepayers) as security for the bonds. The more certain the revenue stream, the lower the financing costs. The Commission would have to approve the collection of this dedicated stream.

In order to further benefit from the low-interest debt, securitized financing also involves adjusting the debt-to-equity ratio. Typical regulated utility projects are financed at approximately 50 percent debt to 50 percent equity. By altering this ratio to include more low-cost debt, the financing costs for the project can be reduced. Table 4-1 (see next page), illustrates the impact of debt securitization on the final production cost of electricity for off-shore wind projects compared to land based wind projects. The figure's securitized financing estimate is based on using 80 percent debt to 20 percent equity compared to 50 percent debt to 50 percent equity for land based wind projects. Off-shore wind projects are assumed to have a five-percentage point advantage in capacity factor compared to land-based wind projects.

The analysis used to create the information in Table 4-1 was to model a hypothetical Wisconsin utility's expansion plan using the Electric Generation Expansion Analysis System (EGEAS).[63] Three rounds of EGEAS modeling were performed. The first modeling run forced in a typical 100 MW land-based wind project to partially meet the RPS objective for the hypothetical utility. For illustrative purposes, this run is assigned a net present value of future revenue requirements of $15,000,000,000. That is, the present value of the discounted future revenue requirements for all the assets and fuel needs for the hypothetical utility, including at

[62] WPSC and WPL are firmly opposed to the use of securitized financing for generating facilities, renewable or otherwise. Securitized financing places all of the risk of generating facilities with the utility, with no offsetting return. Therefore, neither WPSC nor WPL view such financing as a viable alternative for off-shore wind facilities, and objects to the calculation of the cost of such facilities assuming the use of such financing to mask their true incremental cost compared to alternatives.

[63] The EGEAS model selects the optimal combination of generation resources to be constructed in the future, based on forecasted demand and energy, cost of construction for new generation, fuel costs, variable operations and maintenance (O&M) expenses, and fixed O&M expenses for all generating resources – existing, committed, and new generating units.

least one 100 MW land based wind project, are assumed to total $15,000,000,000. A second run used the same data, but forced the selection of a 100 MW off-shore wind project (to replace one 100 MW land-based wind project) with 185 percent of the capital cost of the land-based option and a five-percentage-point improvement in capacity factor. The capital structure was not changed. The third run again forced the selection of the off-shore wind project option, but this time used securitized debt financing to push the capital structure to eighty percent debt and twenty percent equity.

These are conservative estimates regarding the value of securitization. Under securitization, equity can be reduced to a fraction of a percent.[64] Twenty percent equity was left in for this exercise to assure that there would be an incentive for investors in the utility to encourage the choice of an off-shore rather than a land-based wind project. Wind profiles over water in both Lake Michigan and Lake Superior may have even greater capacity factors and superior wind profiles in other respects as well. If wind profiles are such that the capacity factor is more than five percentage points greater than land-based wind projects, or if transmission losses from generation located closer to load improve the economics of off-shore projects relative to land-based projects, the illustrative results shown below would simply be tilted to a more favorable position for the off-shore option.

The results demonstrate that the higher capital cost of an off-shore wind project adds a significant $120,000,000 to the net present value of the future revenue requirements for this hypothetical utility. That is, over the life of the project, the off-shore wind project is $120,000,000 more expensive under these assumptions. Using securitized debt financing under these conservative parameters reduces the increase in the net present value of future revenue requirements to $20,000,000. This is a $100,000,000 reduction compared to the off-shore premium with a traditional capital structure. Of course, securitized debt financing could also be used for land-based projects. If securitized debt financing were used for all wind projects, the cost premium for off-shore projects would continue to tilt decision making away from the off-shore alternative so long as the cost premium was significantly larger than the output premium.

Table 4-1: Impact of Securitized Financing on Final Production Cost of Electricity

Option for an Additional 100 MW of Wind	NPV of the Stream of Future Revenue Requirements	Net Off-Shore Premium	Securitized Debt Financing Savings
On-Shore Traditional Finance	$15,000,000,000		
Off-Shore Traditional Finance	$15,120,000,000	$120,000,000	
Off-Shore Securitized Debt Finance	$15,020,000,000	$20,000,000	$100,000,000

[64] In docket 6630-ET-100, Wisconsin Electric Power Company proposed that the capitalization of the special purpose entity be perhaps as low as, but no lower than, 0.5 percent equity. (October 12, 2004, Financing Order in docket 6630-ET-100, pg. 12.)

The table shows that securitized financing significantly lowers the final production cost of electricity from an off-shore project. However, the dedicated revenue stream shifts the project risk to the ratepayers. While it reduces the risks to the utility's stockholders, it also reduces the amount of equity on which the stockholders can earn a return. Wis. Stat. § 196.027, the "environmental trust financing" legislation, allows securitized financing for pollution control equipment. To extend this to cover off-shore (or on-shore) wind projects would require a policy determination by the state that this is appropriate use of the mechanism, and potentially a legislative change to expand the statute's scope.

4.2 Cost Sharing and Other Grants

Most off-shore wind project funding in Europe has been through cost sharing and grants. Cost sharing and grants are valuable to investor-owned utilities, independent and merchant power producers, and public power organizations because they are an effective means of reducing upfront capital costs. However, as noted in the IGCC report, the Electric Power Research Institute reports that applicants have in the past been required to repay 100 percent of the government's actual cost-sharing contribution to the project upon demonstration of successful commercialization.[65] Under such an arrangement, the benefits are reduced. Neither the federal government nor any state has enacted cost sharing or grants for off-shore wind projects.

4.3 Tax-Based Incentives

4.3.1 Investment Tax Credit

Investment tax credits provide the taxpayer a credit against regular income tax otherwise due based on a percentage of taxpayer investment in specified equipment and facilities. Investment tax credits have high value for investor-owned utilities, but no value for public power organizations which do not pay taxes. The value to independent and merchant power producers depends on their profitability. The investment tax credit provides additional cash flow in the early years of the project. For the taxing agency, the investment tax credit reduces revenues in the year the incentive is taken. However, the revenue loss will decline over time as a result of lower depreciation in subsequent years due to tax basis reduction.[66]

EPAct 2005 provided for investment tax credits equal to 20 percent of the eligible investment in IGCC plants. The eligible investment is any property which is necessary for the gasification of coal, not the entire IGCC plant. A similar construct at the Federal or State level could be created for off-shore wind projects. The Investment Tax Credit could target the incremental construction costs associated with off-shore wind projects such as the increased cost of the tower structure.

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[65] Electric Power Research Institute. "A Coal Fleet Working Paper: Financial Incentives for Deployment of IGCC." March 10, 2005, pg. 5.
[66] Oakley, Brian T. "Deploying Integrated Gasification Combined Cycle Units: What Will it Take?" June 27, 2005.

4.3.2 Production Tax Credit

A production tax credit provides the taxpayer with a credit against income tax otherwise due based on the amount of energy actually produced from a facility, rather than on the capital cost of the facility. The difference between the production tax credit and the investment tax credit is that the production credit is allowable only to the extent the facility actually produces electricity while an investment credit is available without regard to the level of performance of the facility so long as it has been placed in service.[67] The owner receives no benefit unless the technology is successfully implemented.

Production tax credits have been in place, almost always for a fixed number of years of new construction, for wind-based generation in the U.S. To further enhance the likelihood of off-shore wind, a larger production tax credit could be established for electric generation from off-shore wind projects.

4.3.3 Accelerated Depreciation

Accelerated depreciation is a tax-based strategy that has high value for independent and merchant power producers, medium value for investor-owned utilities, and no value for public power organizations which do not pay taxes. Accelerated depreciation shifts depreciation to the present, but does not increase the overall deduction, resulting in no additional deductions over the asset's life.[68] However, the accelerated depreciation results in lower taxes at the beginning of the asset's life, and consequently, increases cash flow. Its benefits come from the time value of money.

4.4 Credit-Based Incentives

4.4.1 Loan Guarantees

Loan guarantees permit a project sponsor to obtain debt financing at an interest rate closer to the guarantor's cost of money. A loan guarantee may permit a higher leveraged capital structure, substituting low cost debt for high cost equity. Non-recourse loan guarantees can also shift a portion of a project's technology risk to the guarantor.[69] Loan guarantees have high value for independent and merchant power producers, low value for investor-owned utilities, and no value for public power organizations. Investor-owned utilities with lower credit ratings receive more benefit than investor-owned utilities with higher credit ratings. Loan guarantees can minimize federal costs while providing significant project benefits. The risk borne by the guarantor depends on the ability of the owner to service and repay the loan. Assured revenue streams substantially reduce that risk.

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[67] Electric Power Research Institute. "A Coal Fleet Working Paper: Financial Incentives for Deployment of IGCC." March 10, 2005, pg. 6.
[68] Oakley, Brian T. "Deploying Integrated Gasification Combined Cycle Units: What Will it Take?" June 27, 2005.
[69] Electric Power Research Institute. "A Coal Fleet Working Paper: Financial Incentives for Deployment of IGCC." March 10, 2005, pgs. 4-5.

EPAct 2005 established a loan guarantee program to provide up to 80 percent federal loan guarantees to gasification technologies. No similar federal programs have been enacted for off-shore wind.

4.4.2 Securitized Financing

Securitized financing pledges an asset as security for the bonds. First mortgages are the best known and simplest form of securitization. However, in recent years, the term securitization often refers to revenue streams pledged to service and repay the debt. The more certain the revenue stream and its assured adequacy to service and repay the debt, the lower the financing costs. With securitization, the debt leverage can be increased substantially, lowering the financing costs further.

2003 Wisconsin Act 152 created Wis. Stat. §196.027 enabling environmental trust financing. Under Wis. Stat. §196.027, utilities can securitize environmental control activity which includes costs associated with the construction and installation of environmental control equipment for an existing energy utility plant and the associated retirement of the old equipment. The statute allows the securitization of the securities with environmental control property, which is the right to collect environmental control charges that are authorized in the Commission's irrevocable order. If bonds are issued pursuant to this statute, retail customers will have to pay monthly non-bypassable charges to recover the principal, interest, and related costs of the bonds. The interest on these bonds is not tax-exempt.

Some comments were received that the cost savings from Environmental Trust Financing are more likely from a lower cost of debt (the interest rate paid), rather than the example given in this report which has both lower financing costs and increased leverage (more debt and very little equity financing). The potential for increased leverage appears to be one of the intended benefits anticipated in the drafting of the enabling legislation in Wisconsin. The ability to both increase leverage and the ability to reduce the cost of debt both are a function of how well the bond community views the value of the dedicated revenue stream that secures the debt. Both the enabling legislation and any required action to dedicate the revenue stream paid by ratepayers in a Commission order need to be viewed as irrevocable and real for the bond community to react positively to the securitized debt with respect to both the extent of the leverage and reduction in the interest rate on the underlying bonds. The expectation on the quality of the securitization will also be critical to making sure that there is no adverse impact on the non- securitized debt in the remainder of the utility's financing portfolio.

4.4.3 Leased Generation Financing

Leased Generation Financing is a provision in Wisconsin law that allows a utility to secure generation via a lease with an affiliate at fixed terms for the expected life of the asset. By using a lease rather than traditional rate-based financing, the payments for the new generation are a fixed stream over time rather than a depreciation-based revenue requirement. This has the potential to minimize rate impact in the early years. As noted by WP&L in its application to use Leased Generation Financing in the Sheboygan Falls combustion turbine docket, care needs to be taken in determining the implied Return on Equity (ROE) in the lease. Simply using the same

ROE that is prevailing in a rate case may result in higher overall payments on the lease than would have occurred under a traditional rate-based financing. The leased generation approach may allow for lower debt financing than under traditional rate-based financing. The potential exists to lower the total cost to ratepayers and to lower the initial rate impact to ratepayers for new generation.

4.4.4 Direct Loans and Tax-Exempt Financing

Under this arrangement, a governmental agency issues bonds and uses the proceeds to make a loan to the project owner to cover a portion of the cost of the facility. These bonds are referred to as Private Activity Bonds. Two dimensions of the financing are important – whose credit backs the securities (governmental agency or project) and whether the interest on the securities is tax-exempt. Generally, the interest rate is close to those of the lending agency if the bonds are backed by the agency's credit. Independent and merchant power producers have more use for direct loans than investor-owned utilities because of their lower credit ratings. Public power organizations can issue their own tax-exempt bonds and often can borrow at rates lower than the federal government. Consequently, they do not benefit from direct loans. The governmental agency may also issue revenue bonds where the underlying credit is the project. Private Activity Bonds may have limited appeal if they are not tax-exempt. Eligibility for federal tax-exemption is based on meeting U.S. Department of Treasury Internal Revenue Service rules, which include purpose and aggregate issuance limitations.

4.5 Regulatory Incentives

The PSCW can also be a source of financial incentives. Through its ratemaking process, it can accelerate the recovery of investment costs, provide incentive returns on off-shore project investments, ensure timely recovery of preconstruction costs and financing costs during construction, and provide incentives to purchase electricity produced by an independent or merchant power producer. The costs of such incentives would be borne by the ratepayers of the utility involved, not the state's taxpayers.

4.6 Other Incentives

4.6.1 RPS advantage

In the United Kingdom, off-shore wind is offered an advantage over land-based wind projects. Electricity generated from off-shore projects is allowed to be multiplied by a factor of 1.5 so every 100 MWhs of off-shore wind is counted as 150 MWhs for compliance with the national renewable portfolio standard. This provides an incentive to promote early adoption of what is viewed as an essential component of future generation needs. It is expected that off-shore wind will be counted 1.5 times compared to land-based generation only until the technology has matured.

4.6.2 Guaranteed Purchase of Power at a Specified Price

Rhode Island has issued and received seven responses to a Request for Proposals for a 400 MW off-shore wind project capable of generating 1.3 million MWhs of energy for five years beginning in 2012. The state will allow the energy to be used to meet the Rhode Island 15 percent renewable portfolio standard. Any energy beyond the 1.3 million MWhs may be sold into the wholesale market. Rhode Island chose to structure the RFP so the wind energy project would be privately owned, but with guaranteed sales, it is anticipated that the private entity will be better able to secure financing.

4.7 Summary

The cost differential between off-shore wind projects and on-shore or conventional generation could be a barrier to the development of off-shore wind. There are avenues for the State or the PSCW to develop incentives to make up for the perceived risk and the cost premiums associated with off-shore wind. Some financing options already exist that could provide incentives, but the impact or attractiveness of these vary by who is building the project – a utility, a public power organization or an independent or merchant power producer. Other options that were reviewed exist for other types of projects, but may be adaptable to off-shore wind. These would require statutory changes at the state and federal level.

5. ENVIRONMENTAL CONSIDERATIONS FOR OFF-SHORE WIND

Without a specific project location or a specific design for a proposed project, an analysis of potential environmental impacts is difficult. As such, this section of the report addresses the full range of environmental impact concerns that should be addressed in the evaluation of a proposed off-shore wind project. For each topic area, the Human Environment Work Group identified the concern, summarized what is known about the potential for impacts, made a relative comparison to the impacts of a land-based wind project, and highlighted research and data needs.

5.1 Birds and Bats

The fact that birds and bats collide with wind turbines on land is well known and documented.[70] Behavioral effects such as displacement/avoidance and reproductive interference are also a concern. In addition, dead bats have been increasingly found around turbines, raising the concern that this slow reproducing group of species could also be adversely affected by wind projects. A poor understanding of bird and bat usage of the Great Lakes makes predictions of impacts from off-shore wind facilities to bird and bat populations difficult, and relatively little research has been conducted on methods to mitigate such impacts.

Birds and bats face many challenges in their life history, including safely avoiding obstacles in their flight paths. Experts have estimated that cumulatively worldwide, hundreds of millions of birds are killed each year in collisions with communication towers, windows, electric lines, and other structures.[71] Cumulative estimates are not available for bats, but land-based studies suggest that mortalities are likely similar to birds. For both birds and bats, flight patterns and responses to structures, habitats and weather conditions may all have an effect on risk, and those effects may vary based on the environment in which the animals are moving and carrying out their normal functions. Wind facilities will affect that environment and the behavior of the animals in ways that are poorly understood.

From the beginning of commercial wind energy development, wildlife impacts have been a concern. For example, when fatalities of raptors, including golden eagles and red-tailed hawks, were documented at the Altamont Pass wind developments in California, a series of actions and studies were initiated that are still in progress. The original California study[72] identified a number of factors that may contribute to these collision fatalities, including the characteristics of the site and the behavior of the birds themselves.

[70] NRC, 2007: Environmental Impacts of Wind Energy Projects, National Academies Press, USA, 376 pages.
[71] Klem, D., Jr. 1989. Bird-window collisions. Wilson Bulletin 101:606–620; Klem, D., Jr. 1990. Collisions between birds and windows: mortality and prevention. Journal of Field Ornithology 61:120–128; Dunn, E.H. 1993. Bird mortality from striking residential windows in winter. Journal of Field Ornithology 64:302–309; Shire, G.G., et al. 2000. Communication towers: a deadly hazard to birds. American Bird Conservancy, Washington, D.C.
[72] Orloff, Susan and Ann Flannery, 1992, Wind Turbine Effects on Avian Activity, Habitat Use and Mortality in Altamont Pass and Solano County Wind Resource Areas, 1989 – 1991, 301 pp.

The off-shore wind industry is in its infancy (the first off-shore wind project was built in 1990 off the Swedish coast) and, consequently, there has only been limited research into the impacts on birds and bats from off-shore turbines. Concerns arose that the reported effects on terrestrial species of birds would be repeated on water and sea birds. Studies in Holland [73] and Great Britain[74] have investigated these matters and suggested some possible influences and mechanisms of interactions. Some of these included the orientation and distance between turbines, which could affect the birds "comfort" with flying between turbine structures, and the relationship between the turbine placement and important resources. Although European studies supply some information on the collision risks, the importance of project location in determining the risk of bird collisions with turbines is just as apparent from off-shore studies as from on-shore results.[75]

In addition to collisions, other potential impacts from off-shore turbines are displacement and flight avoidance responses (birds are displaced from ideal feeding or nesting grounds by the presence of turbines, or avoid them on daily movements or during migration), and habitat loss/modification (physical habitat loss under foundations or the creation of novel feeding and resting opportunities that actively attract birds to the turbines). An additional concern is whether required lighting on wind towers will actively attract birds to the turbines, especially during poor weather conditions during migration.

There are contradictory observations at different sites, making it difficult to establish a clear pattern. For example, Kuvlesky et al.[76] state, "Research in Europe indicate(s) that wind energy projects located off-shore can also be responsible for high collision mortality for waterbirds" and "A number of predevelopment studies in Europe suggest that wind energy project development could displace migrating and breeding waterfowl and shorebirds due to disturbance associated with wind energy project construction and post-construction maintenance, disruption of daily movements, or disruption of migration activity." Extensive monitoring of two Danish off-shore wind projects found that birds showed avoidance responses (DONG Energy et al. 2006).[77] On the other hand, the Draft Environmental Impact Statement (EIS) for the Cape Wind Energy Project, located in Nantucket Sound off the coast of Massachusetts[78] concludes: "Based on research cited and information discussed in this report, with respect to effects resulting from habitat modification, human disturbance, and risk of collision, the overall

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[73] Winkelman, J. E., 1995, Bird/Wind Turbine Investigations in Europe, Appendix 2B, Proceedings of the National Avian-Wind Power Planning Meeting, Denver, Co, 20 – 21 July, 1994.
[74] http://www.off-shorewind.co.uk/Pages/Publications/Archive/Birds/
[75] Langston, R. H. W. and J. D. Pullan. 2003. Windfarms and birds: an analysis of the effects of windfarms on birds, and guidance on environmental assessment criteria and site selection issues. BirdLife International. Convention on the Conservation of European Wildlife and Natural Habitats. T-PVS/Inf(2003)12. 58 pp.
[76] Kuvlesky, W. P., Jr., L. A. Brennan, M. L. Morrison, K. K. Boydston, B. M. Ballard, and F. C. Bryant. 2007. Wind energy development and wildlife conservation: challenges and opportunities. Journal of Wildlife Management 71:2487-2498.
[77] DONG Energy, Vattenfall, The Danish Energy Authority, and The Danish Forest and Nature Agency. 2006. Danish Off-shore Wind – Key Environmental Issues.
[78] U. S. Department of Interior. 2007. Programmatic Environmental Impact Statement for alternative energy development and production and alternate use of facilities on the Outer Continental Shelf. Minerals Management Service, OCS EIS/EA, MMS 2007- 046.

operational impacts of the proposed action to non-threatened and endangered avifauna are assumed to be minor."

5.1.1 Bird and Bat use of the Great Lakes Area

While much is known about bird movements on land, and our knowledge of bat movements over land is increasing, bird and bat distribution, abundance, behaviors and movements over and on the off-shore waters of the Great Lakes are poorly documented. Langen[79] has characterized this knowledge as "surprisingly little."

Volunteer and academic bird counts have been conducted in the shoreline counties of Lake Michigan for many years, but counts are only accurate within the range of optical instruments at the observation point, both horizontally and vertically. Species identifications are difficult, and accurate counts are hard to obtain. Therefore, the data needed to make a reasonably accurate estimate of potential adverse impacts of wind projects off-shore is very limited. Detailed studies of spring and fall migrations, as well as summer/breeding season and winter usage of near and distant off-shore areas, are likely to be more difficult and thus more costly than land-based studies. However, if towers are to be sited to have the least impact on birds, scientifically valid studies are essential. Costs, at least to study nocturnal migration, could be kept down if monitoring equipment (acoustic and radar) can be co-located such as on meteorological towers, with the data collected remotely.

John Idzikowski of UW-Milwaukee has monitored radar tracking of birds migrating nocturnally through the Great Lakes region. He indicates that the behavior of migrants, their general distribution (both vertically and horizontally) and movement timing is consistent across the entire region, but often dependent on and affected by factors such as dawn and sunset times, cloud cover, moon phase presence, winds aloft, frontal passages and especially storms encountered once migration has commenced. There are birds migrating over the Great Lakes on most nights during the peak periods from mid April to late May, and again from mid-August through late September. Most large movements are initiated by warm front passage or southerly wind flow patterns on the western side of high pressure systems in spring, and cold front passages in the fall resulting in a northerly wind flow. More information on this topic can be found in Appendix E.

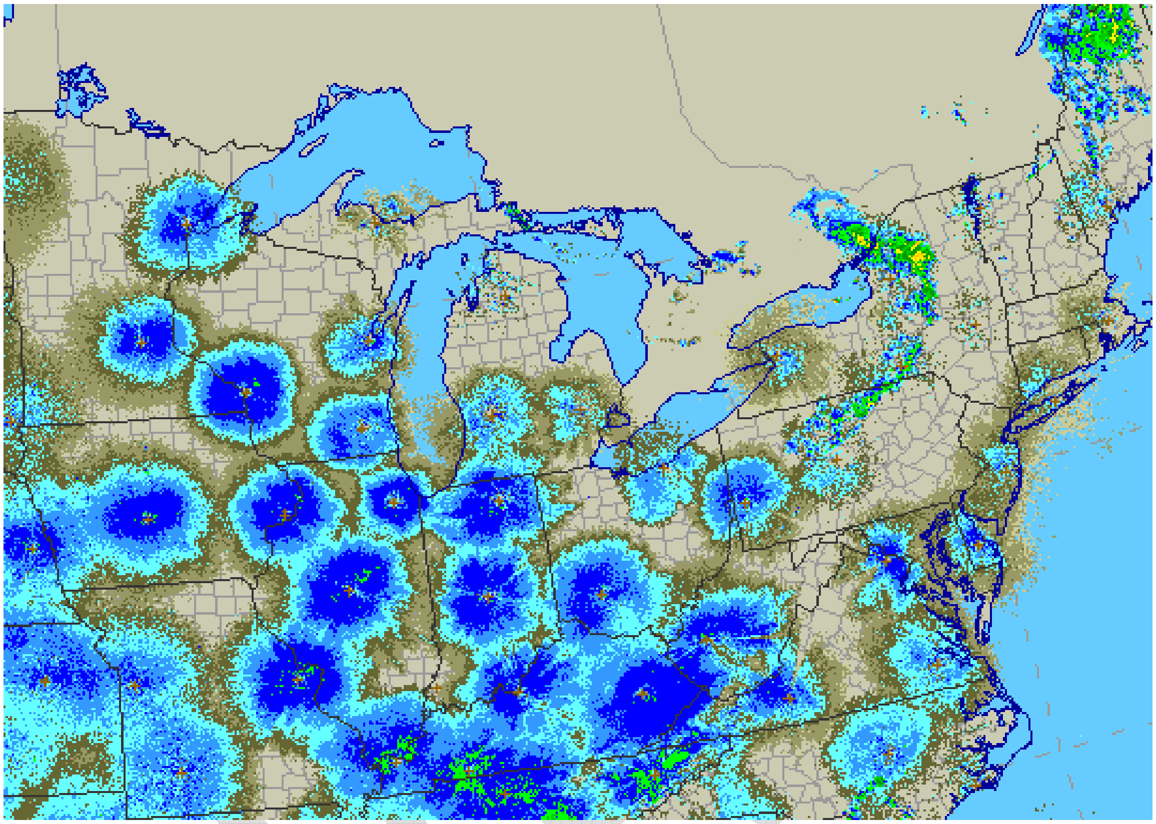
Other experienced observers note bird use patterns in which migrant birds seek fall-out locations at dawn to rest and feed (Idzikowski 2005; Diehl et al. 2003). They tend to take the shortest path from the lake to these areas, and descend steeply. If turbines are between the nocturnal flight corridors and these stop-overs, descending birds may face increased risks of collision. In addition, the FAA marking lights on the wind structure may actively attract birds to the turbines, which could place them at risk from the rotating blades (Gehring and Kerlinger 2007).

[79] Langen, T. A., M. R. Twiss, G. S. Bullerjahn, and S. W. Wilhelm. 2005. Pelagic bird survey in Lake Ontario following Hurricane Isabel, September 2003: observations and remarks on methodology. Journal of Great Lakes Research 31:219-226.

On and along the Great Lakes are well known geographical leading lines, which are linear features that direct the movements of wildlife, often forming corridors that may extend several miles out into the lake. There are also concentration areas that are used by diurnal migrant birds, for example, well-defined harbors such as the Milwaukee Harbor probably have been used by wintering diving ducks and gulls since the post-glacial formation of the Great Lakes and the return of those species. These areas should be identified and considered when planning wind facilities.

The Great Lakes shoreline includes several identified Important Bird Areas and bird stopover locations (refer to Appendix F for details). The following radar image from the University of Colorado Center for Atmospheric Research shows the type of information available depicting the exodus of birds from numerous stop-over locations in the Eastern US on a night of heavy migration. The density of birds can be extrapolated between these stations to indicate a continuous wave of migrating birds over the entire are around the "donuts", including over the lakes. Filling in between the spots indicates that an even greater number of birds are flying at this time than the map alone would suggest. A number of these stop-over sites are along the coasts of the two Great Lakes bordering Wisconsin, and birds resting at those locations are likely to continue to follow the lakeshore as they continue their migrations. Birds will avoid flying over the lakes when they can see the water. However, they often overfly the lakes when they are already aloft, and conditions do not allow them to see that they are over the water. This data does not allow identification of the types of birds and their numbers with any precision, nor can we determine the distribution of species within these large groups from this data. Flight heights over the lakes are also incompletely documented. Observations indicate water birds flying at less than 450 feet, and nocturnal migrants greater than 400 feet, except during bad weather.

Figure 5.1: The Evening Exodus of Birds From Stopover Locations in the Eastern U.S., Including the Great Lakes Region.



Source: The University Corporation for Atmospheric Research

Similar patterns occur with bats, but are perhaps limited to migrations where they are known to fly along with groups of migrating birds (mainly songbirds). Some red bats are known to use the western Lake Michigan shoreline corridor, where the bats concentrate on westerly winds in fall, followed by many diurnal migrant birds.

Food availability in the harbor areas and near shore areas, such as Milwaukee and Green Bay, may be very important to attracting resident and migrant water birds, but little detail is available to quantify that subject. The near-shore benthos, plankton, and the associated food chain, up to small fish, are very important to certain bird species, though much of what we know is anecdotal. For example, scaup dives are probably less than 50 feet in depth, with most dives less than 20 feet, while long-tailed ducks are reported to be deep divers at 100 feet plus, and goldeneyes are often seen diving in water of 25 to 50 feet. The red-breasted merganser is usually considered the deepest-diving duck, and is often seen outside breakwaters. Overall, more than 90 percent of activity for both wintering and migrating diurnal ducks occurs within 1,000 meters of shore, with various species using different depths.

In addition, the food availability conditions in the near-shore areas are changing. For example, zebra and quagga mussels are now attracting diving ducks to near-shore areas that were not used in the recent past. Diets have changed from an array of native invertebrates and small fish to primarily mussels. Historically, the most abundant wintering duck species on the Great Lakes, greater scaup, fed at dusk and at night and rested during the day. Currently, they dive regularly during the day as they flock over mussel beds. Before the invasion of mussels, separate areas were used for feeding and resting and there were late afternoon flights of thousands of birds to the feeding areas. The mussels have altered the food chain by filtering water so efficiently that small plankton has decreased, which has decreased the larger planktonic invertebrates such as the amphipod Diporeia. Long-tailed ducks, which feed on Diporeia, no longer winter on the western Great Lakes, and they are now uncommon as migrants. Scoters, in contrast, have increased dramatically in numbers apparently in response to zebra mussels.

5.1.2 Threatened and Endangered Species

Special attention should be given to estimating the impact of off-shore wind facilities on state and federally-listed threatened and endangered species, as well as those species listed by the WDNR as state special concern species and state species of greatest conservation need. More than 70 percent of Wisconsin's 116 rare bird species migrate along the Great Lakes shoreline and/or over the lakes. The population impacts of even a small amount of mortality or some displacement of birds during migration are much more significant for rare species populations than for the more common species.

There is only limited knowledge on migration routes of some of the state endangered and threatened species including: trumpeter swan, great egret, snowy egret, piping plover, peregrine falcon, red-necked grebe, osprey, red-shouldered hawk, Caspian tern, common tern, Forster's tern, yellow-throated warbler, cerulean warbler, worm-eating warbler, Kentucky warbler, and hooded warbler. Another species that might be affected is the federally endangered Kirtland's warbler, which was recently discovered to be nesting in Wisconsin, and which winters in the Bahamas. Research is needed to determine which of these species warrant the greatest attention during siting investigations, and for developing mitigation measures.

5.1.3 Research Needs

Recently, Wisconsin's Focus on Energy program funded a proposal titled "Development of a Research Proposal to Obtain Bird Data in Off-Shore Areas of Southwestern Lake Michigan to Facilitate an Evaluation of the Potential Impacts to Birds of Off-Shore Wind Development." The objective of this work, which is scheduled to be completed in January 2009, is to develop a plan for collecting bird data in off-shore areas of southwestern Lake Michigan to facilitate an evaluation of the potential impacts to birds of off-shore wind development in this region.

Before an assessment of potential impacts to birds and bats from off-shore wind turbines in Wisconsin waters can be undertaken, more information is needed on use of the airspace and waters in this region by both groups. Among the more important questions that need to be addressed are:

- What are the nocturnal and diurnal movements of migratory birds and bats near- and off-shore in Lakes Michigan and Superior?

- What affects nocturnal migrants movement to shore when daylight arrives?; and

- What are the daily and seasonal movements of waterbirds off-shore and where do they aggregate off-shore during migration or winter?

In addition to research needs to assess bird and bat use of the lakeshore and open water areas, research is needed on the potential impacts to these species from wind facilities including:

- Will birds or bats be attracted to off-shore turbines due to night lighting or other factors and what effect does weather and visibility have on this?

- How will bird strikes be detected, enumerated and evaluated at off-shore wind projects?

- Can wind turbines be designed or supplemental measures be undertaken to mitigate avian impacts?

5.2 Fisheries and Aquatic Resources

In general, relatively little is known about the interactions between off-shore wind power facilities and fish, fisheries, and aquatic resources, particularly in freshwater. Much of the information that is available is associated with marine fish species in marine environments. Therefore while some generalizations can be made, it should be understood that important differences exist.

In addition to the fundamental differences between freshwater and marine ecosystems, it should be noted that the Great Lakes are largely a “closed” ecosystem, as compared to a marine environment. Only one percent of the water in the lakes is renewed by precipitation each year, and it takes a very long time for water to flush through the lakes - almost 200 years in Lake Superior and 99 years in Lake Michigan. Current aquatic communities in the Great Lakes are under stress from multiple causes, such as invasive species and nonpoint source pollution. These and new future stressors could affect the ability of some native species, such as lake trout, to naturally reproduce and thrive.

5.2.1 Habitat

Much of the research and knowledge about important aquatic habitat and spawning grounds is focused on near-shore[80] areas, which tends to be where many fish species are concentrated. The Great Lakes Spawning Atlas[81] shows the known spawning locations for many

[80] For biological purposes, near-shore waters are defined by the biological communities present, rather than distance from shore or depth of water.
[81] Goodyear, C. S., T. A. Edsall, D. M. Ormsby Dempsey, G. D. Moss, and P. E. Polanski. 1982. Atlas of the spawning and nursery areas of Great Lakes fishes. 14 vols. U. S. Fish and Wildlife Service, Washington, DC. FWS/OBS-82/52. http://glein.er.usgs.gov/introduction.html

species, particularly near-shore species. We know less about the open water ecosystems of the Great Lakes and the critical habitats associated with those ecosystems.[82]

There is a potential for wind facility structures to create valuable fish habitat. Depending on the location (deep or shallow water) and the type of structure, it may be possible to design an installation to facilitate the recovery of some species, such as lake trout. If research and observations of actual wind installations confirm this hypothesis, the added value of that fish habitat should be considered during decommissioning. In some cases, it may be preferable to leave at least part of the structures in place, provided they are not a navigational hazard.

Any proposed projects should consider impacts to state or federal threatened or endangered species. Currently, there are no state or federal threatened or endangered fish or other aquatic species in the open lake waters of Lake Michigan or Lake Superior.

5.2.1.1 Near-shore

Near-shore waters provide productive spawning grounds and valuable habitat for numerous species of fish, aquatic life and birds. Near-shore areas, particularly those with suitable spawning substrate, should receive special consideration related to the effects of the placement of wind turbines. If wind turbines are placed in areas with suitable spawning habitat, efforts to retain the character of the substrate should be made. In addition, impacts of construction activities on fish should be minimized by avoiding certain time periods when fish populations may be particularly vulnerable, such as spawning activities.

The placement of transmission lines is expected to have localized and relatively temporary impacts on aquatic habitat, particularly if directional drilling at the land-water interface can prevent the disruption of aquatic habitat near the shore. With any directional drilling operation there is the potential for frac-outs, i.e. the release of drilling mud used during the drilling process through fractures in the underlying rock, which could impact habitat in the immediate vicinity of the release of drilling mud.

5.2.1.2 Off-shore

Deep Basins

Relatively little is known about the off-shore ecosystems of the Great Lakes, making it difficult to assess the potential habitat and fishery implications of turbine placement in deep water. However, the presence of off-shore wind turbines could provide a platform to perform research to further our scientific understanding of this ecosystem.

[82] Dr. John Janssen with the Great Lakes WATER Institute is researching the ecosystems associated with Lake Michigan's mid-lake reef complex. This website summarizes some of his research: http://www.glwi.uwm.edu/people/jjanssen/

Reefs and Shoals

Relatively shallow off-shore areas of Lake Superior and Lake Michigan are often used as spawning locations for various fish species, particularly lake trout. Lake trout populations in Lake Superior are naturally reproducing and support some commercial fishing. Lake trout populations in Lake Michigan are under significant stress from multiple sources, including invasive species and pollution, and are not self-sustaining. The mid-lake reef complex in Lake Michigan appears to be central to the long term restoration of lake trout populations. Recent research has found that lake trout are spawning in the mid-lake reef complex in Lake Michigan and that some of those eggs are surviving to hatch. This may be due, in part, to reduced pressure from invasive species such as alewives in off-shore waters. The WDNR is currently proposing to focus its lake trout stocking efforts around these off-shore reefs, in the hope that it will encourage natural lake trout reproduction.

Off-shore reefs with suitable spawning substrate, such as the mid-lake reef in Lake Michigan, should receive special consideration related to the effects of the placement of wind turbines. If wind turbines are placed in areas with suitable spawning habitat, efforts to retain the character of the substrate should be made. In areas without suitable spawning habitat, it may be advantageous to utilize anchoring materials that are conducive to spawning of lake trout and other species to increase the amount of available spawning habitat.

The placement of transmission lines is expected to have localized and relatively temporary impacts on off-shore aquatic habitat. Similarly, impacts of construction activities on fish can be minimized by avoiding certain time periods when fish populations may be particularly vulnerable, such as spawning activities.

5.2.2 Lake Currents, Sediment and Nutrient Flows

While one turbine could act like a crib or buoy a large number may impact the direction or velocity of local lake currents, which may affect the movement (distribution and transport) of plankton, the patterns or mechanics of sedimentation, nutrient movements, or the seasonal movements of fish. Disturbing nutrient-rich sediment during construction and/or maintenance could have local (probably short-lived) effects on plankton. Possible changes in local currents and sediment transport should be investigated. Studies have been done in marine locations, but not within the Great Lakes.

5.2.3 Aquatic Invasive Species

The introduction of aquatic invasive species (AIS) in Wisconsin waters is of continued concern, particularly in the Great Lakes. However, there appear to be few particular concerns related specifically to the construction and operation of off-shore wind turbines. The deployment of construction equipment and vessels for wind turbine construction has similar risks of spreading AIS as other marine activities. Therefore, appropriate disinfection and ballast water procedures are warranted. In addition, the possibility that environmental changes resulting from wind turbine construction and operation could prove advantageous to particular AIS should be investigated on a case-by-case basis. For example, turbine platforms and anchoring systems may provide additional areas for zebra and/or quagga mussels to colonize. Given the extent of existing mussel colonization throughout Lake Michigan, this may not result in significant additive impacts. However, it may be prudent to design structures to be less attractive to particular AIS where possible.

5.2.4 Contaminated Sediments

Areas of sediments contaminated with toxic substances are located throughout the Great Lakes region, concentrated primarily in harbors and off-shore of urban areas.[83] Turbine construction and transmission cable placement, including any directional drilling activities, have the potential to disturb contaminated sediments or uncover buried deposits. Disrupting these areas can re-suspend contaminants and make them available for biological uptake. Areas with known sediment contamination should be avoided - most of these areas are very near shore or within harbors or tributaries. There may be unknown historical dumping sites in deeper waters. While locating a wind project in such a "hot spot" is unlikely, sediment sampling of the base location is prudent.

5.2.5 Submerged Logs

There are areas of the Lake Superior lakebed that contain submerged logs - old-growth trees that were harvested, became waterlogged and sank more than a century ago. The trees may create valuable fish habitat in some cases, and there may be some demand for the trees themselves as a rare and unusual source of old-growth wood. However, because they are found in relatively limited areas, submerged logs are unlikely to be a major issue for the development of off-shore wind resources.

5.2.6 Electromagnetic Fields

Though the potential for subtle behavioral changes to fish populations associated with electromagnetic fields in the immediate vicinity of underwater transmission lines may warrant consideration, dramatic effects on fish populations are unlikely. Fish species found in the Great Lakes may use the earth's electromagnetic field to navigate and migrate, but lack special organs such as those used in prey detection by sharks and rays, which has been a subject of concern in some marine wind projects.

5.2.7 Noise

Subsurface sound resulting from construction (dredging, pile driving, etc.) and operation could affect fish and other aquatic organisms. Information is needed specific to the sensitivities and responses of Great Lakes species to sound generated during construction and operations.

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[83] More information about contaminated sediments, including a map of known contamination sites in Wisconsin, is available from http://WDNR.wi.gov/org/water/wm/wqs/sediment/index.htm. Some of the most severely contaminated sites have been designated as "Areas of Concern" in accordance with the Great Lakes Water Quality Agreement between Canada and the U.S. For more information about these areas, refer to http://WDNR.wi.gov/org/water/greatlakes/priorities/aocs.html.

5.2.8 Spills and Discharges

Each turbine contains oil in its gearbox, and may contain oil in an oscillation damper or power transformer. The quantity of oil will vary by turbine manufacturer. For reference, a 1.65 MW turbine contains approximately 1,033 gallons of oil. In addition, off-shore substations would require transformer oils, and transmission lines may be insulated with small amounts of oil.

There are risks of oil spillage associated with the construction and operation of an off-shore project. For example, there is a small risk that a ship could run into a turbine foundation and subsequently cause an oil spill, or an anchoring vessel could rupture a transmission line, releasing a small amount of oil. Other types of accidents could affect either turbines or a substation.

Oil spills in any water body, particularly a relatively closed freshwater system that serves as a drinking water supply for millions of people, are best avoided. Spills can have negative impacts on fish, wildlife and aquatic communities.

However, because it is extremely unlikely that any spill or accident would affect multiple turbines at one time, there is a minimal risk of releasing a large quantity of oil during the operation of an off-shore wind project. Though any potential oil spill would be very unlikely to pose a major threat to aquatic communities, all actions to reduce the potential for oil spills into the Great Lakes should be taken.

5.3 Commercial and Recreational Fishing

Lake Michigan and Lake Superior support sizeable commercial, tribal and recreational fisheries valued at over $1 billion. Therefore, maintaining or enhancing the economic and cultural components associated with these fisheries is a priority. Section 5.2 describes the potential biological impacts (positive, neutral and negative) of the construction and operation of off-shore wind turbines on fish populations. This section focuses on the impacts on the operation of commercial and recreational fisheries. It should be noted that most, but not all, commercial and recreational fishing activities take place within roughly three miles of shore, although some level of fishing activity occurs throughout Lake Michigan and Lake Superior.

The primary species of commercial and recreational harvest in Lake Michigan and Lake Superior include bloater chub (*Coregonus hoyi*), lake herring (*Coregonus artedi*), yellow perch (*Perca flavescens*), smallmouth bass (*Micropterus dolomieu*), whitefish (*Coregonus clupeaformis*), lake trout (*Salvelinus namaycush*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), smelt (*Osmerus mordax*), walleye (*Sander vitreus*), coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Oncorhynchus mykiss*), and Chinook salmon (*Oncorhynchus tshawytscha*). In addition, there are ongoing successful efforts to reestablish populations of spotted muskellunge (*Esox masquinongy*), lake sturgeon (*Acipenser fulvescens*), and coaster brook trout (*Salvelinus fontinalis*). The following table presents the primary species of commercial and recreational interest as well as their preferred spawning habitat and spawning times in Lake Superior and Lake Michigan.

Table 5.1: Primary Fish Species of Commercial and Recreational Interest in Lake Superior and Lake Michigan

Species	Spawning Substrate	Spawning time	Commercial	Recreational
Bloater	Various	September-March	X	
Lake herring	Various	November-December	X	
Yellow perch	Various	May-June	X	X
Whitefish	Shoals, rock, gravel, and cobble	October-December	X	
Lake trout	Rocky bars and shoals, rock	October-December	X	X
Brook trout	Gravel (primarily in tributary streams)	October-December		X
Brown trout	Rocky areas along the shore and gravel cobble areas in tributary streams	October-December		X
Smelt	Shallow gravel areas in tributary steams and along shore	March-May	X	X
Coho salmon	Gravel in tributary streams	October-November		X
Chinook salmon	Gravel and cobble in tributary streams	September-October		X
Muskellunge	Vegetation and muck in shallow bays	April-May		X
Lake sturgeon	Rock and boulder in tributary rivers	April-May		X
Smallmouth bass	Gravel and cobble	May-June		X
Rainbow trout	Gravel and cobble in tributary streams	Skamania: July-September Chambers Creek: February-April Ganaraska: March-May		X

Source: Fishes of Wisconsin. Becker, 1983

5.3.1 Catchability

Some fish species have been shown to gather around structures installed in the lake bed or around floating structures. This behavior may occur for a number of reasons including the concentration of piscivorous fish attracted by increased density of forage fish. Concentrations of fish may facilitate their capture by commercial and recreational fishers. Increased catchability can be dealt with through regulations limiting catches to sustainable levels. However, it is important to consider this possibility prior to construction in order to put any necessary regulatory changes in place.

5.3.2 Gear

Gillnets, trawls, and live entrapment gear (including trap nets and pound nets) are three primary methods used for commercial fishing in Lake Superior and Lake Michigan. Numerous commercial fishermen and Native American tribes participate in these fisheries. There are potential conflicts between all three types of gear and wind turbines. Depending on the particular characteristics of a proposed wind turbine development, these conflicts may be more or less intense. Seasonality and spatial specificity of commercial fishing activities may reduce the conflicts. For example, construction of wind turbine facilities could be restricted to times when fisheries are closed or fishing intensity is low.

In very broad terms, commercial fishing activities occur in the following areas of Lake Michigan and Lake Superior, with the following types of gear:

- Trap nets (and pound nets) for whitefish are deployed in relatively shallow near-shore areas (less than 150 feet) for whitefish in Green Bay and for yellow perch and whitefish along the western shore of Lake Michigan. Similarly, trap nets are deployed for whitefish in near-shore areas of Lake Superior. Trapnets and pound nets are around 1000 to 1500 feet in length, with a height of up to 50 feet. Trap and pound nets are used on soft substrate areas of the lake. Given their size, these gears would be difficult to deploy around off-shore wind turbines, and would pose a risk of entanglement.

- Gillnets are used primarily for whitefish, yellow perch and bloater chubs, generally in near-shore areas in Green Bay and along the western shore of Lake Michigan. Gillnets are set for lake herring and whitefish in relatively shallow near-shore areas in Lake Superior. Although not generally targeted, lake trout are also captured in gillnets. Gillnets can be over a mile in length and are generally anchored on the bottom but may drift depending on environmental conditions.

- Trawling for smelt occurs primarily in Green Bay, and along the western shore of Lake Michigan in waters greater than 60 feet. No trawling currently occurs in Lake Superior. Anchoring structures for off-shore wind turbines may limit the use of bottom trawls around the wind turbines.

- Commercial fishing and recreational fishing for lake trout do not occur in the mid-lake lake trout refuge although recreational fishing for other species is permitted in this area.

Similarly, no commercial or recreational fishing is allowed in the refuge around the Apostle Islands in Lake Superior. A more detailed description of these refuges can be found in the WDNR Fishing Regulations.[84]

While the majority of recreational fishing for a variety of species primarily occurs in areas within three miles of the shore, fishing activity also occurs out to ten miles from shore and occasionally further in Lakes Michigan and Superior, and in Green Bay. Although recreational boats may be able to navigate between wind turbines, they often use downriggers, a steel cable with a large round weight attached, which could become entangled in the anchor lines of off-shore wind turbines.

5.4 On-Shore Impacts

As outlined in the engineering sections of this report, the construction of an off-shore wind facility will require on-shore land impacts associated with lay down yards, staging areas, port facilities, substation improvements, and the connection to the transmission system. None of these types of activities are unique to off-shore wind, as applicants and regulatory agencies routinely address siting and operations issues related to natural resource and land-use management issues.

Regardless of where the actual interconnection point is located, it will be incumbent upon the developer to document any sensitive environmental, cultural, or societal areas including environmentally sensitive areas, aquatic and terrestrial wildlife, areas of cultural significance, and potential societal points of concerns including hospitals, schools, and day cares.

5.5 Human Welfare and Health

5.5.1 Visual Impacts including Shadow Flicker

The visual impact of wind facilities has been a major concern for the siting of both land-based and off-shore projects. The 650 miles of Great Lakes shoreline in Wisconsin includes numerous park and recreation areas, many miles of public roadways, and many private riparian dwellings. These public and private amenities provide experiences from wilderness to high use beaches, marinas, and ports in very urban settings. People value the lake front for many reasons, and the view is one of the more important reasons. Depending on the site location, size of the turbines, number of turbines, site orientation and lighting requirements, off-shore wind turbine developments will present different degrees of visibility to people on-shore or on the water. For any energy development project, including wind projects, photo-simulations can help interested people assess the visual impacts of a proposal.

Since there currently is not an actual proposal to evaluate, the following photo-simulations are presented as examples of the kinds of visual impacts that may result from off-shore wind developments, and the utility of photo-simulations to assess those impacts. These images were developed for the New Jersey Clean Energy Program to show what a large wind project might look like when viewed from shore, if the project was three miles off-shore or

[84] http://WDNR.wi.gov/fish/regulations/2008/documents/fhregs0809.pdf#lkmi

alternatively if it was six miles off-shore. Each image shows how the visual impact might be different under clear or hazy conditions.

Figure 5.2: Photosimulations of Wind Projects at Three and Six Miles Off-Shore Under Clear vs. Hazy Conditions

Source: New Jersey Clean Energy Program

One issue where off-shore wind projects do not raise concerns relates to the shadow flicker. As wind turbine blades rotate, they cast a shadow upon objects below. A strobe effect can occur where the shadow of the rotating blades cause rapid changes in light intensity. Because wind turbines are designed to turn and face into the wind, the potential shadow flicker is less when the wind direction is perpendicular to the direction of the wind turbine shadow. By contrast, the potential shadow flicker is greater when the wind blows from a direction near parallel with the wind turbine shadow. No shadow flicker occurs when the turbine blades are not rotating, on overcast days or at night. Shadow flicker impacts are affected by the total height of the turbine, blade diameter and the proximity of sensitive receptors. At distances greater than 1,000 feet the shadow flicker problem is seen only when the sun is low on the horizon. Flicker impacts, when they occur, are transitory and generally short-lived.

Two types of concerns have been raised regarding shadow flicker: (1) possible epileptic seizures, and (2) annoyance. Epileptic seizures can sometimes be triggered by certain frequencies of flashing or flickering lights. This is a fairly rare condition known as photosensitive epilepsy. Around one in 200 people have epilepsy and of these, only two to five percent have photosensitive epilepsy. Photosensitivity is more common in children and adolescents and becomes less common after the mid-twenties. The frequency of flashing light most likely to trigger a seizure varies from person to person. Some literature indicates the frequency of concern is between five and 30 Hz. Other literature identifies the frequency of concern as between 16 and 25 Hz. While some people are sensitive at higher frequencies, it is uncommon to have photosensitivity below five Hz. Wind turbines currently being installed in Wisconsin generally produce shadow flicker frequencies at or slightly above one Hz under normal operating conditions.

Annoyance can occur when the shadow from moving turbine blades falls on a home causing a pulsing light effect inside the residence. In such situations, annoyance while reading or watching television may occur. Simple steps can sometimes be taken to minimize the annoyance level.

Applicants for authority to construct and operate wind projects in Wisconsin are required to conduct an analysis of shadow flicker impacts for each project. Computer models such as *Windfarmer* are used to prepare these analyses. Shadow flicker can be an issue if sensitive receptors such as residences and hospitals are within the area of the turbine shadow. On terrestrial sites in Wisconsin, recently installed turbines have a total height of about 400 feet. The impact from shadow flicker diminishes significantly with distance from the turbine. For off-shore turbine installations the trend is for larger turbines and blades. Prototype 7.5MW turbines with 150meter (492 feet) blade diameters and 100 meter (328 feet) towers are now being tested. Total turbine height for such a turbine would exceed 570 feet. Even at this height, off-shore installations two or more miles from shore are not likely to produce shadow flicker impacts to sensitive terrestrial receptors such as residences and hospitals.

5.5.2 Air Quality

The activities necessary for construction, maintenance and decommissioning of a Great Lakes wind project could potentially have air quality impacts. The primary sources of air emissions from these activities would be mobile sources and fugitive emissions from project vehicles and construction equipment that burn liquid fossil fuels, typically diesel fuels. Combustion of liquid fossil fuels produces emissions of PM10, CO, NOx, SO2, VOC, HAPs and GHG, and may also produce objectionable odors. Fugitive dust emissions from land disturbance at the land/water interface and transmission inter-connection are a secondary potential source of emissions, and any such emissions may be regulated under Wis. Adm. Code § NR 415.04. Ancillary construction activities, such as painting and degreasing, are a third potential source of emissions. Although some air pollution control regulations may apply to an off-shore wind project, it is unlikely that such a project would require a pre-construction air permit.

The location of an off-shore project (and thus the source of many of the emissions associated with the project) may be more remote from sensitive human receptors, such as schools and hospitals, than a typical terrestrial project. Construction, maintenance, and decommissioning activities would likely add only an insignificant, temporary incremental contribution to air emissions in project areas. The draft EIS for the *Cape Wind* project concluded that emission impacts from that project would be minor, public health and visibility impacts would be negligible, and the net air quality impact (considering avoided emissions) would be positive.[85]

5.5.3 Waste and Materials Management

Many of the project parts and materials are likely to be pre-fabricated and will not require construction at the staging area or project site. However, as with any large project, an off-shore wind project will generate large quantities of waste during the construction and operation phases. The expected wastes include solid wastes (such as construction materials, trash, etc.) and liquid wastes (e.g., paints, oils, etc.). These materials would be subject to relevant waste management regulations and ordinances and the project developer would be expected to have a waste management plan prior to commencing construction. Such plans would typically address collection (including characterization and segregation of waste materials), temporary storage, and transport to on-shore transfer stations or recycling and disposal facilities. Some of the wastes generated by an off-shore project could potentially be categorized as hazardous and would potentially be subject to more stringent federal and state regulations, including manifest requirements. Disposal of wastes in the Great Lakes would not be permitted.

To the extent that a wind project displaces the need for energy from fossil fuel power plants, the "net" impact during the operational phase in terms of solid and hazardous wastes may in fact be positive. This would hold true especially if energy from a coal-fired power plant were displaced, due to the large amounts of coal ash that must be managed.

Decommissioning of a wind power installation will require an on-shore facility capable of processing large quantities of steel, fiberglass and other materials for recycling or disposal. Some of these materials will have high value in recycling markets, while others might not be recyclable for technological or economic reasons.

Most of the wastes associated with an off-shore wind project will be similar to those associated with terrestrial projects in terms of the types and quantities of materials. Some waste

[85] Refer to Section 5.3.1.5 of Draft EIS at http://www.mms.gov/off-shore/alternativeenergy/CapeWindDEIS.htm.

materials unique to operation in an off-shore environment can be expected and project developers may be expected to characterize any such materials prior to commencing construction.

5.5.4 Spills and Discharges

Many of the materials that are needed to construct, maintain, operate and decommission an off-shore wind project have the potential to contaminate land or water or to otherwise impair human use and enjoyment of natural resources. Vessels going to and from a project site may contain a variety of fluids including diesel fuel and other oils, and trash and debris may be accidentally lost overboard from these vessels. Depending on the voltage used for transmitting electricity from the turbines to shore, transmission cables may be insulated with mineral oil. If these cables were ripped open, for example by a ship's anchor, the mineral oil would be released. Lake bottom materials, potentially including contaminated sediments, may be re-suspended into the water column when turbine foundations or cables are laid or when directional drilling is used to connect the project to on-shore infrastructure. Finally, on-shore activities associated with the project could be a source of soil erosion, storm water discharges, or spills.

The most direct and immediate threat from spills and discharges is the threat to aquatic resources, which was discussed above. However, a variety of impacts on human welfare and health are also possible, including harm to commercial and recreational fishing, aesthetic impairment and harm to tourism, nuisance litter and odors, and contamination of soil or water that ultimately could impact drinking water resources or property values.

The likelihood of a major spill from an off-shore wind project is probably very small, in part because the vessels and equipment associated with this type of project do not typically use large volumes of hazardous materials. In any event, experience has shown that most of the potential impacts of these discharges and spills are preventable.

5.5.5 Noise

Noise impacts caused by generation projects can arise when pre-project ambient noise levels are exceeded for any significant period of time. The type, frequency, intensity and duration of sound produced by a project are important factors to consider. Noise impacts are estimated by analyzing the anticipated sounds produced by the construction and operation of generation projects and comparing those estimates to the pre-project ambient noise environment. A pre-construction ambient noise analysis and a post construction noise assessment, using the PSCW's Noise Measurement Protocol, are standard requirements for all generation projects proposed for PSCW approval. Projects are normally assessed for both temporary noise impacts associated with construction and for long-term operational impacts.

5.5.5.1 Construction, Maintenance, and Decommissioning Impacts

Short term noise impacts during construction of terrestrial turbine installations can be a concern for residences along delivery routes and for residences located near turbine sites. Noise impacts would be associated with increased truck traffic needed for the delivery of construction materials to the turbine sites. In addition, noise from heavy equipment used for installing facilities such as service roads, collector circuits, and substations as well as the delivery and installation of the turbines themselves are assessed.

For off-shore projects, most construction, maintenance and decommissioning activities would take place a considerable distance from residences and other sensitive noise receptors. Noise impacts would arise from the delivery, storage, and assembly of project materials (tower sections, turbines, blades, and other construction materials). Staging and storage areas are likely to be located at or near commercial ports. Sensitive receptors located near port facilities may or may not experience some noise impact beyond what is typical for that port. Noise analyses would consider port activities, as well as the types of land, water and air transport vehicles likely to be used, and the proximity of sensitive receptors.

5.5.5.2 Turbine Noise Impacts

Because off-shore wind projects would most likely be sited at a considerable distance from shore, turbine noise may be less of an issue than it is for many terrestrial wind projects. Wind turbine noise is typically produced by either mechanical or aerodynamic sources. Mechanical noise is created by bearings, gear housings, cooling fans, yaw drives, and the generator itself. The tower and nacelles may also conduct or transmit mechanical noise. Methods for reducing mechanical noise in wind turbines include: using low-speed cooling fans, special finishing of gear teeth, adding baffles and acoustic insulation to the nacelle, using vibration isolators and soft mounts for major components and using low rpm turbines. Noise characteristics vary with manufacturer, and some manufacturers are exploring direct drive technologies that might completely eliminate gear housing noises.

Aerodynamic noise is created when the turbine blades cut through the air. Noise generated by wind turbines depends on the wind speed and the design of the turbine. Some off-shore turbines are designed to rotate at higher speeds than a typical terrestrial turbine and therefore, all else being equal, may create more aerodynamic noise. Over the years, improvements in technology and turbine design have reduced overall noise levels around turbines. Low-frequency impulsive noise from wind turbines has, in the past, been a subject of some concern. Low-frequency impulsive sound is found primarily in downwind turbine designs. Downwind turbines face in the direction the wind is blowing. This means that the wind encounters the turbine blades only after passing by the turbine structure itself. The turbine structure causes turbulence which results in short duration load fluctuations on the turbine blades, resulting in acoustic pulses or thumps.[86] By using upwind turbines (turbine blades face into the wind), reducing the rotational speed of the turbine blades, and incorporating pitch control on turbine blades, the overall noise profile of a turbine can be reduced.

Noise impacts associated with wind turbine facilities are difficult to assess because of the scattered nature of turbine placement. In addition, perceived impacts largely depend on the distance to and number of nearby turbines, the sensitivity of the receptors, wind speed and direction, time of year, the type of structures or vegetation existing between the turbine and the receptor, and turbine manufacture and design. In general, the noise produced by wind turbines

[86] Hubbard, H. H. and K. P. Shepherd. 1990. Wind Turbine Acoustics. NASA Technical Paper 3057. 46pp.

tends to be less noticeable than the noise produced by other industrial facilities. Ambient sounds, including natural sounds, frequently tend to mask turbine noise. In addition, modern turbines have features that reduce noise emissions, have relatively slower blade rotation and would have setback distances from non-host residences. These factors tend to limit noise impacts.

For an off-shore facility the noise propagation from the turbines to shore should be evaluated for potential impact. The process for estimating noise impacts for off-shore facilities would be essentially the same as that used for terrestrial sites. This would involve an assessment of ambient noise levels in the project area and a comparison of the estimated noise produced by the turbines.

As a point of comparison, the Draft EIS for the proposed *Cape Wind* project which will be 4.6 miles from shore concluded that the “proposed action is expected to be largely inaudible to recreational boaters” and “the proposed action is anticipated to be inaudible at shoreline locations.”[87]

5.5.6 Electromagnetic Fields

EMF (also referred to as electromagnetic or magnetic fields) is produced only when electrons move along a conductor; the strength of the field is directly proportional to current flow. The magnitude of the magnetic field decreases with distance from the source. Public concern about EMF centers on the perception that exposure to power frequency (60Hz) EMF may affect human health. After over 30 years of research, a scientific consensus has developed that exposure to power frequency EMF is unlikely to present a significant danger to human health. Because the public continues to express concern about EMF exposure, EMF estimates for electric industry construction projects are required as a routine part of any electric construction application.

Sources of EMF from a turbine project include the turbine generator, turbine transformer, collector circuits and substation facilities needed to connect to the electric grid. The key issue for any turbine installation is exposure. At off-shore sites, EMF exposure will be limited because the turbines and most of the collector circuits will be far removed from sensitive receptors such as residences, schools, daycare facilities and hospitals. EMF exposure issues are likely to be limited to areas where the underwater cable from the wind collector system comes on to dry land and make its way to the substation facilities. In this respect, an off-shore facility faces the same EMF issues as terrestrial electrical facilities.

Computer models can estimate the magnetic fields likely to be produced by turbine collector circuits and substation facilities. These estimates can be easily prepared and made part of any siting application.

[87] Pages 5-14 and 5-15 of Draft EIS at http://www.mms.gov/off-shore/alternativeenergy/CapeWindDEIS.htm.

5.6 Other Impacts on Human Activities

5.6.1 Cultural and Traditional Resources

The Great Lakes have long provided a bounty of resources to be harvested, as well as a means of transportation. Prehistoric and historic communities built campsites, villages, cities, and other “sites” along the margins of the Great Lakes and elsewhere, leaving evidence in the form of prehistoric camps and villages (including some early prehistoric sites located in once dry but now inundated areas of the Great Lakes), historic towns, shipwrecks and other associated features. Consequently, archaeological sites (both prehistoric and historic) and historic structures (e.g. buildings and bridges) dot the lake-margin landscapes and lie beneath the Lakes’ waters. Collectively, such sites and structures are referred to as “historic properties” or “cultural resources.”

Millennia of exploration, community life, travel, commerce and recreation on the Great Lakes have left an impressive array of submerged cultural sites along Wisconsin's shorelines and on the lake bottoms. Both pre-contact and post-contact archaeological and cultural sites are submerged under the waters of the Great Lakes. Cultural resources in the form of villages, campsites, special use areas, cemeteries, shipwrecks, and other maritime related features are present on Wisconsin’s lake bottoms.

Pre-contact sites submerged under the waters of the lakes include villages/campsites, cemeteries and special-use sites. Post-contact sites include: Native American community sites, which may include cemeteries, special use areas, as well as shipwrecks and a variety of dock and other maritime facilities. The exact number, location and nature of these resources are not clear because large scale surveys have not been completed. Additional systematic surveys and analysis may result in the development of a model that allows for the identification of sensitive areas. It seems likely that the majority of submerged cultural resources would be determined eligible for listing on the National Register of Historic Places.

Tribal consultation is very important. Concerns of tribal government may include a wide range of issues, including but not limited to: identification and protection of archaeological sites, historic structures, and traditional cultural properties (TCPs, i.e., sites important to a community’s historically rooted beliefs, customs, and practices); protection of near-shore rice harvesting areas; protection of (tribal) commercial fishing practices and fish restoration areas; maintenance of the area’s scenic viewshed/cultural landscape/wilderness quality; tourism; and others. These relatively concrete issues relate directly to sites and structures, traditional practices, tribal economics, and general quality of life. Perhaps less tangible, but no less real, are tribal perspectives which link communities to the Great Lakes in a profoundly spiritual sense (e.g., origin stories).

The presence of historical, commercial, spiritual, commercial, or recreational sites does not necessarily preclude a site from being developed, but it does require extra effort and close collaboration with all potentially affected parties.

5.6.1.1 Shipwreck Submerged Sites

Working in partnership with a variety of individuals, organizations and agencies, the State Historical Society has developed an inventory of 750 underwater archaeological sites, 650 of these are historic shipwrecks. The current inventory of 650 historic shipwrecks has been developed from archival research and limited field surveys. The current inventory does not represent a complete listing of shipwreck sites located on Wisconsin's lake bottoms. Existing distributional patterns represent the biased nature of the current information and not actual distributions. The vast majority of Wisconsin's Great Lakes bottoms have not been surveyed for the presence of cultural resources.

The shipwrecks are underwater museums and time capsules that contain a wealth of information that is not available from any other source. They include not only the remains of the ship, but also the clues to its loss, the cargo it was carrying, personal items that the crew carried with them, and sometimes the remains of the crew members. These remains are protected from disturbance under Wis. Stats. § 157.70. The discovery and investigation of the shipwrecks acquaint us with the lives of everyday men and women, the builders, the sailors and the longshoremen who lived, and sometimes died, on the nation's waters.

5.6.1.2 Non-shipwreck Submerged Sites

The recent geological history of Lake Superior and Lake Michigan is complex and the nature and extent of changes in the lakes and water levels in the lakes over the last 14,000 years are not entirely clear. What is clear is that portions of the current bottom of Lake Superior would have been accessible for human occupation about 3,500 years ago and large expanses of the Lake Michigan bottom would have been accessible for human settlement beginning 9,000 years ago. The sites created by the occupation of these "new" lands would include large villages and community sites, special-use sites such as fishing or shell fishing stations, and cemeteries. The artifact inventories from these sites may include a variety of Native American watercraft and other classes of artifacts that are not preserved in dry land settings.

Utilizing the information derived from surveys on land, likely site locations in areas that were exposed but are now submerged include former beach ridges, sheltered areas along former shorelines, and former river and lake confluences. The size, nature and location of the rivers and streams flowing into the lakes have changed over time, and as a result, the identification of these relic river channels and lake confluences may be a key to identifying early sites.

Perhaps the most accessible and important resource for identifying previously recorded historic properties is the Wisconsin Historical Society's (WHS) "Wisconsin Historic Preservation Database" (WHPD) website, a subscription-based system that provides detailed information in the form of maps and data that describes the locations, type and character of sites and structures which occur on Wisconsin lands and within its waters. The quality of maps and data varies, and is especially poor for non-urban structures. WDNR has a subscription to the WHPD for the Departmental Archaeologist. The WHS can be relied on to provide additional information for these sites and structures.

5.6.2 Recreational Boating

The Great Lakes are a vast resource for recreational boating for the State of Wisconsin residents and its many visitors. Lake Michigan boasts over 75 marinas and at least 25 yacht and boating clubs. There are a variety of recreational activities on the Great Lakes for boating including: water skiing and tubing; kite sailing; operation of personal water craft and recreational boats cruising, which range in size from 16 foot boats with outboards to 40 plus feet yachts and cabin cruisers; recreational anglers who use a number of different craft; sailing; kayaking; and scuba diving. These activities can be done by the individual, or can be organized as an event. There are several events like regattas, point-to-point sailing races, speed boat racing and fishing tournaments that are carried out each year. While much of the activity is relatively near shore, much of the lake area is used at one time or another by recreational boaters.

Concerns for recreational boating created by off-shore wind projects include: potential for obstructing or restricting use of free lanes of navigation for the boater during construction and maintenance activities; changes to traditional navigation during operations of the facility; confusion for visitors to Wisconsin waters; and possible delayed response time for emergency personnel.

Most safety concerns can be addressed by proper marking and posting of the facility on charts and maps used in maritime navigation.

Any effects on boaters could impact marinas, ports, yacht clubs and associated businesses located along Wisconsin's shoreline of Lake Michigan and Lake Superior.

Section 5.6.5 addresses the potential for impact to marine-band radio operations.

5.6.3 Commercial Shipping

The U.S. Army Corps of Engineers has established and maintains federal navigation channels in the near-shore shallow waters of Lakes Michigan and Superior. The federal navigation channels are periodically dredged to maintain adequate water depths for commercial vessels. Most federal channels are located in close proximity or entirely within harbor areas with the exception of an approach channel that extends from the Green Bay Harbor for 17 miles into the waters of Green Bay. More detailed information on federal projects can be found on the USACE Detroit District's website.[88]

Federal navigation channels should be avoided if possible, including the location of submerged transmissions lines within or across federal project areas. Any project that may interfere with the operation and maintenance of federal navigation projects would require coordination and authorization from the USACE Detroit District.

Off-shore wind development may present potential navigational hazards to commercial vessels. In deeper open waters, ships generally follow recommended navigation course lines, but

[88] http://www.lre.usace.army.mil/_kd/go.cfm?destination=Page&Pge_ID=2119

are not required to follow established course lines.[89] Any structures would be reviewed by the U.S. Coast Guard and would be required to meet applicable regulations, including for marking as aids to navigation. It is expected that any project proponent would be required by the Coast Guard to conduct navigational safety risk assessments. Any structures associated with off-shore wind development, including submerged transmission lines, would be reported to the federal Defense Mapping Agency and the National Oceanic and Atmospheric Administartion (NOAA) for mapping on the Great Lakes Nautical Charts.

Anchorages used both frequently and infrequently such as those used as “safe harbor” in bad weather, should be avoided. Potential conflicts with anchorages become less likely if wind projects are located several miles from shore. Designated anchorages in Wisconsin include Madeline Island, Sturgeon Bay, Fish Creek Harbor and Milwaukee Harbor. The locations and geographic extent of these anchorages are defined in detail in 33 C.F.R. Part 110 of the U.S. Coast Guard regulations.[90]

Section 5.6.5 addresses the potential for impact to communication systems important to commercial shippers.

5.6.4 Air Traffic

If a wind project is located near an airport, a permit may be required from the Wisconsin Department of Transportation (WisDOT), depending on the height of the structure. Concerns about the effects of a wind project on air transportation at public use airports may include affecting the descent minimums or approach patterns for an all-weather instrument approach.

5.6.5 Communications

Wind turbines can potentially interfere with various electronic signals and modes of communication. The potential areas of concern are summarized below.

5.6.5.1 Radar

Radar is a critical tool for aviation and marine safety and navigation, as well as for national security. Radar works by sending out a radio frequency pulse and noting any echoes that are returned when the pulse bounces off of objects in its path. The time between the pulse and the echo establishes the distance to the object. Off-shore wind turbines are large enough that they should be detected by any radar system, but the rotating blades can potentially “confuse” the radar system, causing false echoes or miscalculation of distance. Furthermore, a single turbine, or more importantly an array of off-shore turbines, can potentially shield or block the radar detection of other objects in the vicinity or behind the turbine(s). This can be an important consideration for planes and fast-moving boats, or in low-visibility conditions.

[89] Great Lakes shipping recommended course lines can be found on navigational charts, and can also be mapped through the Great Lakes Information Network’s GIS system: http://gis.glin.net/map_explorer.php?lake=michigan
[90] http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title33/33cfr110_main_02.tpl

Experience to date from European off-shore wind projects has shown that the turbines have some impact on marine radar systems, but these impacts have, thus far, not led to any safety problems. Impacts on aviation radar may be more problematic. Tests in the early part of this decade by the U.S. Air Force and Britain's Ministry of Defence discovered that wind turbines may create blind spots in air defense radar systems. Based on those results, the Federal Aviation Administration temporarily halted work on several terrestrial wind power projects in the Midwest, and the British Ministry has routinely objected to any wind turbines within the line of sight of defense radar systems. Wind energy developers contend that these concerns were exaggerated. However, in June 2008 the Ministry of Defense and the British Wind Energy Association reached agreement on a memorandum of understanding that addresses technological solutions.[91]

5.6.5.2 Marine Radio

Ships and boats on the Great Lakes use very high frequency (VHF) radio signals for ship-to-ship and ship-to-shore communications. Specific frequencies are assigned by the Federal Communications Commission for routine marine radio service and others are set aside for emergency services. During construction projects, contractors often use two-way radios, but there is almost no overlap in marine band frequencies and the frequencies used by those radios, so little or no interference with communications would be expected. Operating wind turbines, however, can interfere with VHF radio signals, especially when the transmitter or the receiver is close to a spinning turbine or when a turbine tower lies between the transmitter and the receiver.

The Draft EIS for the *Cape Wind* project concluded that the proposed project would have minor impacts on communications, including marine radio and emergency frequencies, and most of those impacts would be limited to within one half mile of the project site.[92] Research and actual experience to date from operating off-shore wind projects in Europe mostly appears to support this conclusion. For example, one report by the United Kingdom's Maritime and Coastguard Agency on the North Hoyle off-shore wind project found that "the wind energy project structures had no noticeable effects on any voice communications system, vessel to vessel or vessel to shore station." The same report, however, found that VHF equipment in lifeboats did not function correctly when within 50 meters of turbines.[93] Another study by the consultants Elsam Engineering on the *Horns Rev* project in Denmark concluded that those turbines "do not have any significant effect on VHF communications" and that a number of vessels with different types of equipment have operated in the area without problems.[94]

5.6.5.3 Microwave Communications

Wind turbines can interfere with microwave communications by blocking transmitted signals. Microwave frequency bands range from 900MHz to 40GHz and support a wide variety of communications including: long-distance and local telephone service, cellular phone communications, mainframe data interconnections, the internet, and utility network controls.

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[91] Refer to http://www.berr.gov.uk/files/file46583.pdf.
[92] Refer to Section 5.3.4.4 of the Draft EIS at http://www.mms.gov/off-shore/alternativeenergy/CapeWindDEIS.htm.
[93] Refer to http://www.mcga.gov.uk/c4mca/northhoyle_ver_2.pdf.
[94] Refer to http://www.mms.gov/off-shore/PDFs/CWFiles/26.pdf.

Potential interference with microwave communications is analyzed for every proposed wind turbine project reviewed by the PSCW. Typically, on terrestrial sites, a microwave path analysis is conducted by the applicant for microwave towers within and near (50 miles) a proposed turbine project area in order to insure that turbines do not interfere with line-of-sight microwave transmissions. A similar analysis can be prepared for any off-shore installation. Off-shore wind projects should be sited so there is no possibility of disrupting existing microwave pathways.

5.6.5.4 Television Reception

The video portion of television transmissions can be affected by the presence of a turbine between the transmitter and the receptor. Television audio signals are not affected. Television video signals striking turbines can result in diffraction of the signal, primarily caused by the tower. Signal reflection can also be caused by the rotating blades. Diffraction and reflection cause time delays in signal reception resulting in ghosting and image scintillation on receiving televisions. For digital transmissions, pixilation of the signal map occur.

Interference usually occurs where signal strength is relatively weak. Television signal interference from utility power lines and equipment is covered by Wis. Adm. Code § PSC 113.0707. The PSCW requires each applicant to take reasonable measures to eliminate significant interference. In addition to careful siting, practicable mitigation measures may include improving and adjusting antennas and installing cable or satellite systems.

During the approval process, off-shore wind projects can be analyzed for the potential to cause interference with microwave and television signals. A combination of careful siting and post construction mitigation can reduce or eliminate broadcast signal interference.

6. LEGAL CONSIDERATIONS FOR OFF-SHORE WIND DEVELOPMENTS[95]

Many local, state, and federal agencies and tribal nations would be involved with reviewing the placement of wind turbines in Wisconsin's portion of the Great Lakes. This section identifies the relevant permits and approvals that may be needed for such projects, including the processes and standards that would be applied in decision-making. However, without a specific project to evaluate, there are uncertainties about which regulations may be invoked. The permitting requirements and regulatory approvals necessary will depend on the specific details of an actual proposed project, including its location. Nonetheless, for the purposes of identifying the relevant regulatory requirements, the Legal Work Group assumed that developing and operating an off-shore wind project in the Great Lakes would require the following activities:

- Anchoring foundations to the beds of Lake Michigan or Lake Superior, with footings buried from 20 to 30 meters into the lakebed.

- Installing one cable power line between the turbines to serve as a collector and one or two cable power lines from the off-shore turbines to the on-shore transmission grid. Each line would consist of either one cable with three phases or three separate cables. The cables would be buried to the extent practicable, but where burying is infeasible, the cables would be placed on the lakebed and otherwise protected. At the shoreline, the cables would transition to overhead lines.

- Cofferdams may be necessary for the placement of the cable power lines.

- Depending on their voltage, the power lines could have solid insulation or they may contain small amounts of mineral oil for insulation purposes.

- Placing turbines above the surface of the lake with a platform located partially below the water. Each turbine would contain approximately 1,000 gallons of lubricating and insulating oil.

- Installing a 60 square-foot substation on the surface of the lake that is anchored to the lakebed, with approximately 10,250 gallons of oil used in the transformer.

- Construction activities including but not limited to:
  - transporting materials on barges that would remain in the lakes for several weeks;
  - anchoring barges to the lakebed during turbine construction;
  - placing structures on the lakebed and depositing materials on the lakebed;
  - dredging, boring, directional drilling, or jet plowing beneath the lakebed to install transmission facilities; and

[95] This section is not intended to be nor should it be construed as legal advice.

- o establishing a 15 to 20 acre on-shore staging area near a port to facilitate the transportation of construction materials.

- Maintenance activities for the turbines could include, but are not limited to:
  - o anchoring boats near the turbine platforms or flying helicopters to the turbines to drop off and pick up workers;
  - o anchoring barges to the lakebed or transporting floating platforms using tug boats for major maintenance; and
  - o anchoring other types of vessels, up to 50 feet long, to the bottom of the turbine structure.

- Maintenance activities for the underwater power lines.

- Decommissioning the turbines, including removing some or all of the structures above and below the lakebed.

Many of the regulatory requirements discussed in this section would apply to both terrestrial and off-shore wind projects. Nonetheless, the placement of wind turbines in the Great Lakes would invoke several legal requirements that are unique to projects occurring in aquatic environments. These unique legal considerations have been identified to the extent possible.

6.1 Wisconsin Laws

Off-shore wind projects in the Great Lakes would involve a complicated review under state laws that regulate activities in the waters of the state as well as those regulating utility activities. There are a number of fundamental questions that would need to be addressed before such a project could proceed, including whether existing law authorizes the WDNR to approve structures for wind projects on the beds of the Great Lakes, and if so, whether the entity proposing the project has the authority to construct such facilities. In addition, depending on the size of the project and the type of applicant, the PSCW may have jurisdiction to review the project under existing utility law before construction can begin. Finally, any off-shore wind project would need to comply with other laws that regulate activities that affect the waters and other natural resources of the state.

6.1.1 Approval of Electric Generation and Transmission Facilities in Wisconsin

An off-shore wind project in the Great Lakes would likely be reviewed as two separate projects; one dealing with the construction of the wind turbines and another with the construction of electric transmission facilities. In general, the PSCW has the primary jurisdiction for reviewing and approving electricity generation and transmission facilities in Wisconsin, including wind projects that would be located in the Great Lakes. For those projects that require approval, the PSCW may issue either a certificate of public convenience and necessity (CPCN) under Wis. Stat. § 196.491(3) or a construction authorization under Wis. Stat. § 196.49(3). In addition, electric generation and transmission projects subject to PSCW jurisdiction must meet the requirements of the Wisconsin Environmental Policy Act under Wis. Stat. § 1.11 and the Energy Priorities Statutes under Wis. Stats. §§ 1.12, 196.025, and 196.378(2).

6.1.1.1 Construction Authorization and Certificate of Public Convenience and Necessity - Wis. Stats. §§ 196.49 and 196.491

Electric generation and transmission facilities may be constructed by public utilities, as defined in Wis. Stat. § 196.01(5). Entities other than public utilities may also construct electric generation facilities that are defined as wholesale merchant plants under Wis. Stat. § 196.491(1). As shown in the following illustration, the PSC's jurisdiction over electricity generation and transmission facilities depends on the size of the project and whether the entity proposing the project is a public utility.

Figure 6.1: Determination of PSCW Jurisdiction for Generator Projects

Source: Public Service Commission of Wisconsin (2008)

Large projects - defined as generation facilities with a capacity of 100 MW or greater or transmission lines longer than one mile that are operated at 100 kV or higher - generally require a certificate of public convenience and necessity from the PSC. Smaller electricity generation or transmission projects may require a construction authorization from the PSCW if they are proposed by a public utility and the project meets the cost thresholds established under Wis. Admin. Code § PSC 112.05(3)(a).[96] In contrast, an entity other than a public utility proposing to build a wind project on the Great Lakes with a capacity less than 100 MW would not require PSCW approval prior to construction.

Under Wis. Stat. § 196.49(3), the PSCW may issue a construction authorization if it determines that the proposed project is in the public interest. The PSCW may refuse to issue a construction authorization if a project:

- substantially impairs the efficiency of the public utility;
- provides facilities unreasonably in excess of probable future requirements; or

[96] These thresholds are adjusted biannually according to the procedures in Wis. Admin. Code PSC § 112.05(3)(b).

- adds to the cost of service without proportionately increasing the value or availability of service.

Projects that require a certificate of public convenience and necessity must meet a higher statutory standard of review than projects requiring only a construction authorization. The PSCW may issue the certificate of public convenience and necessity only if it determines that the proposed project meets the criteria established in Wis. Stat. § 196.491. While there are some differences in the procedures for reviewing wholesale merchant plants, the criteria generally include but are not limited to:

- the project meets the criteria for the issuance of a construction authorization under Wis. Stat. § 196.49(3);

- the project satisfies the reasonable needs of the public for an adequate supply of electrical energy, unless it is being proposed by a wholesale merchant plant;

- the design, location, or route of the project is in the public interest, considering alternative sources of supply, locations, routes, individual hardships, engineering, safety, economic, and environmental factors, except that the PSCW cannot consider alternative sources and economic factors for wholesale merchant plants;

- the project will not have undue adverse impacts on the environment, public health and welfare, historic sites, geological formations, land and water aesthetics, or recreational uses;

- the project will not unreasonably interfere with orderly land use and development plans; and

- the project will not have a material adverse impact on the wholesale electric service market.

Because the cost of developing a wind project on the Great Lakes is likely to exceed the threshold for review, a project proposed by a public utility could be expected to require PSCW approval. In contrast, projects proposed by non-utilities would require PSCW approval only if they exceeded 100 MW in capacity. The most significant challenges for an applicant are likely to be the project's environmental impacts, aesthetic effects on-shoreline views, and the comparable costs of alternatives to the project. Moreover, off-shore wind projects are currently more expensive than similar on-shore projects.

Utility facilities, regardless of their location, that are subject to PSCW approval under Wis. Stats. §§ 196.49 or 196.491 may also require WDNR approval under Wis. Stat. § 30.025 if their construction includes activities that require a permit, contract, or approval under Wis. Stat. ch. 30. Wis. Stat. § 30.025 requires pre-application notification, establishes a joint PSCW-WDNR application process, ensures WDNR participation in the PSCW decision-making, and requires WDNR to consider the issuance of PSCW approval as a consideration of practicable alternatives. WDNR is required to issue the necessary Wis. Stat. ch. 30 permits – which are discussed later - if it finds that the proposed facility complies with state and federal environmental standards and that the proposed facilities do not unduly affect: (1) the public's rights and interests in navigable waterways; (2) the effective flood flow of a stream; (3) the rights of other riparian owners; or (4) water quality.

6.1.1.2 Wisconsin Environmental Policy Act–Wis. Stat. § 1.11

The Wisconsin Environmental Policy Act (WEPA) requires state agencies to consider the environmental, socioeconomic, energy, archeological, agricultural, and other effects of a proposed project before issuing permits or other approvals. The PSCW serves as the lead state agency under WEPA for projects that require a construction authorization or a certificate of public convenience and necessity. The PSCW has established guidelines in Wis. Admin. Code Ch. PSC 4, Table 3 for determining whether a project requires a full environmental impact statement (EIS) under Wis. Admin. Code § PSC 4.30 or a less rigorous environmental assessment under Wis. Admin. Code § PSC 4.20. However, the PSCW can choose to prepare an EIS for any project that it believes is controversial or that could significantly affect the quality of the human environment.

Wis. Stat. § 196.025(2m) requires the PSCW to coordinate its review under WEPA with the WDNR and these agencies may prepare a joint EIS for major electric generation or transmission projects. The WDNR's environmental review procedures are set forth in Wis. Admin. Code § NR 150, which identify specific compliance requirements depending on the regulatory actions required by the proposal. Wis. Admin. Code § PSC 4.60 establishes procedures for the development of joint environmental assessments or EISs with other local, state, and federal agencies. Although this provides a mechanism for meeting the requirements of both WEPA and the federal National Environmental Policy Act (NEPA), such joint reviews are difficult in practice because of differences between state and federal decision-making deadlines.

6.1.1.3 Energy Priorities Statutes—Wis. Stats. §§ 1.12, 196.025, and 196.378(2)

Existing law encourages the development of renewable energy sources, including wind power, for meeting Wisconsin's energy needs. Specifically, Wis. Stat. § 1.12(4), establishes the State's energy priorities, in order of importance, as: (1) energy conservation and efficiency; (2) noncombustible renewable energy resources; (3) combustible renewable energy resources; (4) nonrenewable combustible energy resources, including natural gas, oil or coal; and (5) all other carbon-based fuels. In addition, Wis. Stat. § 196.378(2), which establishes the State's renewable portfolio standards, requires public utilities to provide at least ten percent of their delivered energy from renewable sources by 2010. Finally, Wis. Stat. § 196.025(1) requires the PSCW to implement the State's energy priorities in its energy-related decisions and orders to the extent they are cost effective, feasible, and environmentally sound. As a result, these laws would need to be considered in the PSC's evaluation of any Great Lakes wind project that requires a construction authorization or a certificate of public convenience and necessity.

6.1.2 Placing Structures on the Beds of Lakes Michigan or Superior

Under Article IX Section 1 of the Wisconsin Constitution, navigable waters are held in trust by the State of Wisconsin.[97] The State's responsibility to protect the public interest in these waters is known as the Public Trust Doctrine. The public interest in navigable waters has been interpreted broadly to include commercial and recreational navigation, natural scenic beauty, protection of fish and wildlife, preservation of aquatic habitat, protection of water quality, and other uses.

Because the State of Wisconsin owns the beds of all natural navigable lakes and rivers, the State's interest in protecting the public trust extends to the placement of structures on submerged lands or other activities that may impact navigable waters.[98] The Legislature has designated the WDNR as the primary unit of state government responsible for managing the waters of the State under Wis. Stats. §§ 281.01 and 283.01, and has delegated some responsibilities for permitting to the WDNR under Wis. Stats. Chapter 30. However, other state agencies, such as PSCW and the Board of Commissioners of Public Lands (BCPL), may retain jurisdiction over some activities in navigable waters.

The construction of a wind project in the Great Lakes will likely require the placement of structures or the deposit of materials in navigable waters. Although current state law authorizes the placement of electric transmission facilities on submerged lands, there are questions about whether existing law would allow for the construction of facilities such as wind turbines in the Great Lakes. The Work Group identified the following three mechanisms under which the State may possibly authorize the placement of certain structures on the beds of the Great Lakes.

4) Public utilities, as defined in Wis. Stat. §196.01(5), may seek a permit from the WDNR to construct utility facilities on the beds of the Great Lakes under Wis. Stat. § 30.21.

5) Riparian landowners, including municipalities, who own land adjacent to a navigable water body, may seek approval from the WDNR to place structures or deposit materials on the beds of navigable waters under Wis. Stat. § 30.12.

6) Lakebed grants may be made by the Legislature to public entities, including local units of government, for public trust purposes under Wis. Stat. § 13.097.

A lakebed lease may be another mechanism for authorizing off-shore wind, but would first require a statutory revision. Lakebed leases may be made by the BCPL, with approval from the WDNR, to riparian landowners for improving navigation or harbor facilities, or to municipalities for improving or providing recreational facilities related to navigation under Wis. Stat. § 24.39. The statute would have to be amended to include wind projects.

Based on the Work Group's analysis, it appears that the deposit of materials or the placement of structures by persons who are neither public utilities nor riparian landowners may be the most problematic under existing state laws. In addition, there are unresolved questions about the extent of the WDNR's authority to issue permits under Wis. Stats. §§ 30.12 and 30.21

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[97] See article IX, Section 1 of the Wisconsin Constitution.
[98] See *State v. Trudeau*, 139 Wis. 2d 91, 408 N.W.2d 337 (1987)

for activities related to an off-shore wind project. Specifically, the distance to which riparian rights can be extended into the Great Lakes is unclear, which could affect how far from shore structures could be placed. In addition, the WDNR has raised questions about whether facilities associated with a wind project, such as turbines, substations, work barges, transmission lines, and any associated foundations or anchors, could meet the public interest test required for the placement of structures by riparian landowners on the lakebed under existing law.

6.1.2.1 Placing Structures on Lakebeds by Riparian Landowners - Wis. Stats. §§ 30.12 and 30.13

Under common law, riparian landowners in Wisconsin can place only structures in aid of navigation and only in the exclusive riparian zone in front their property without a permit.[99] This common law right is codified in Wis. Stat. § 30.13, and is intended to allow the construction of a pier without a state permit if the pier meets certain criteria.[100] The exclusive riparian zone extends to the line of navigation, which is defined as the six-foot water depth in the Great Lakes.[101] In addition, Wis. Stat. § 30.12 authorizes the WDNR to issue permits to riparian landowners to place structures other than piers or to deposit materials on the beds of navigable waters only if such structures will not materially interfere with navigation, are not detrimental to the public interest, and do not materially affect the flood flow capacity of a stream.

It is expected that off-shore wind projects in the Great Lakes would be located outside of the exclusive riparian zone. Consequently, a riparian landowner could apply to the WDNR for a permit to construct such a project under Wis. Stat. § 30.12. Such an application has never before been considered, and the WDNR has raised questions about the extent of their authority to approve off-shore wind projects under this section. Specifically, the WDNR questions, whether such a project could meet the public interest test required under Wis. Stat. § 30.12(3m) and whether riparian rights can be extended beyond the line of navigation into the lake to a distance sufficient for an off-shore wind project.[102]

6.1.2.2 Placing Structures on the Beds of Lakes Michigan or Superior by Public Utilities - Wis. Stat. § 30.21

Wis. Stat. § 30.21(2), authorizes public utilities to place utility-related structures on the beds of Lake Michigan or Lake Superior, subject to WDNR and PSCW approval. The WDNR has interpreted this section to mean that any structure proposed by a public utility must comply with the same standards as required under Wis. Stat. § 30.12, including the riparian and public interest criteria. Although the WDNR believes that this section could be used by a public utility to apply for a permit to place wind turbines in the Great Lakes, regardless of whether such structures aid in navigation, questions about whether this section would apply beyond the exclusive riparian zone remain.

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[99] See *Northern Pine Land Company v. Bigelow*, 84 Wis. 157, 54 N.W. 496 (1893); *McCarthy v. Murphy*, 119 Wis. 159, 96 N.W. 531(1903)
[100] See Wis. Stat. § 30.01, which defines "pier" as "any structure…built or maintained for the purpose of providing a berth for watercraft of for loading or unloading cargo or passengers onto of from watercraft…."
[101] See Wis. Admin. Code § NR 326.03(4), which defines the riparian zone, also known as the "line of navigation" as the three-foot water depth for most inland waters and the six-foot water depth in the Great Lakes.
[102] Riparian zones are determined according to procedures found in Wis. Admin. Code § NR 326.07.

6.1.2.3 Lakebed Grants - Wis. Stat. § 13.097

One possible mechanism that could be used to authorize the placement of structures on the beds of the Great Lakes is through a legislative lakebed grant. Lakebed grants provide qualified title to grantees for the use of the lakebed only for the specific activities outlined in the grant. The Legislature's authority to grant the use of a lakebed is limited to public trust purposes, which Wis. Stat. §13.097(1)(c) defines as "purposes in furtherance of the public trust in navigable waters established under Article IX, Section 1 of the Wisconsin Constitution". In addition, Wis. Stat. § 13.097(2) requires that, within 15 days of the introduction of a bill creating or amending a lakebed grant, the WDNR must report to the Legislature on the grant's effects on public trust purpose uses, including navigation, fishing, hunting, swimming, recreation, enjoyment of scenic beauty and other public trust purpose uses that will be lost or obtained by the proposed conveyance.

Historically, lakebed grants have been limited to public entities for public projects, such as marinas and park facilities in the near-shore areas of navigable lakes. Whether a grant authorizing the construction and operation an off-shore wind project could be made to a private citizen or corporation, and whether such a grant would be deemed consistent with a public trust purpose is not clear. The Wisconsin Supreme Court uses the following criteria when evaluating whether a grant is consistent with public's interest.[103]

- a public entity will control the use of the area;
- the area will be devoted to public purposes and open to the public;
- the diminution of the lake area will be small when compared with the whole lake;
- none of the public uses of the lake will be destroyed or greatly impaired; and
- the effect on public trust uses is negligible when compared with the convenience afforded to public users.

6.1.2.4 Lakebed Leases - Wis. Stat. § 24.39

Another mechanism that may be used to authorize the placement of certain types of structures in the Great Lakes is a lakebed lease under Wis. Stat. § 24.39. This law authorizes the BCPL to lease submerged lands in Lake Michigan, Lake Superior, the Mississippi and St. Croix Rivers, the Fox River and other bodies of water where the USACE maintains commercial navigation channels[104] to riparian landowners. Before the BCPL can enter into a lease agreement, the WDNR must review the project under Wis. Stat. § 30.11(5), to determine whether the proposed physical changes would be consistent with the public interest. If the WDNR determines that the project is consistent with the public interest, then the BCPL may lease the

[103] See *State of Wisconsin v. PSC*, 275 Wis. 112, 81 N.W.2d 71 (1957).
[104] It is not clear whether areas of lakebed conveyed or granted under Wis. Stat. §13.097 after October 10, 1961 are still subject to the leasing provisions of Wis. Stat. § 24.39.

submerged lands for a period of up to fifty years. The BCPL has discretion in establishing the terms of a lease, including lease payments.[105]

However, lakebed leases are limited by statute to riparian landowners for the improvement of navigation and the construction or improvement of harbors, or for the improvement or provision of recreational facilities related to navigation for public use if the riparian owner is also a municipality. As a result, under current statutes a lakebed lease could not be used for the construction of a wind project in the Great Lakes even if the WDNR found that such a use was consistent with the public interest. Therefore, a statutory change would be necessary before lakebed leases under Wis. Stat § 24.39 could be used for wind projects.

6.13 Other State Laws and Requirements

In addition to meeting the requirements for the PSCW's approval of electric generation and transmission facilities, as well as the WDNR's requirements related to placing structures on the lakebed, any off-shore wind project would need to comply with a variety of other state laws and regulations. The types of permits that may be required will depend on the specific types of construction and maintenance activities required. However, concerns about a proposed project's ability to comply with these requirements would likely be addressed during project design and planning.

6.1.3.1. Placing Electric Transmission Lines on Submerged Lands - Wis. Stat. § 182.017

Wis. Stat. § 182.017 authorizes domestic corporations organized to furnish electricity to the public or for public purposes to construct and maintain electric transmission lines in, across, or beneath a water body if such lines will not obstruct the public's use of the water. The placement of transmission lines in the Great Lakes would be subject to other applicable laws, including Wis. Stats. §§ 30.44 (3m), 30.45, 86.16, and 196.491 (3) (d) 3m, and municipal regulations.

While the PSCW has no special procedures for evaluating power lines placed in or under state water bodies, it reviews all transmission lines - whether on land or water - under the standards established in Wis. Stats. §§ 196.491(3) or 196.49. Therefore, an application for the construction of a high-voltage transmission line in the Great Lakes would need to meet the criteria for issuing a construction authorization or a certificate of public convenience and necessity. Because the PSCW has already approved several transmission facilities above and below Wisconsin water bodies without significant controversy, these requirements are not likely to be a significant obstacle in the approval of an off-shore wind project.

6.1.3.2 Removal of Materials from the Beds of Navigable Waters - Wis. Stat. § 30.20

The construction of off-shore wind turbines or transmission lines in the Great Lakes will likely require some lakebed dredging. Wis. Stat. § 30.20 prohibits the removal of materials from

[105] Lease payments are made into the State's General Fund but ultimately are credited to the Common School Fund.

the beds of navigable waters, such as by dredging, unless such activities are conducted under a contract with the WDNR, authorized by a permit from the WDNR, or authorized by the Legislature. However, if the dredging is incidental to the placement of a turbine and the activity is otherwise authorized by the WDNR under Wis. Stat. § 30.12, the WDNR believes that a project may not require a separate dredging permit under this section. Wis. Stat. § 30.20(1m) authorizes the WDNR to place conditions in permits issued under this section to prevent significant adverse impacts to public rights and interests, environmental pollution, and material injury to the rights of riparian landowners.

6.1.3.3 Navigation Concerns - Wis. Stat. § 30.74

In addition to structures placed on the lakebed, wind projects in the Great Lakes would require the placement of turbines and other facilities on or above the surface of the water. Assuming that the necessary state lakebed permits and federal approvals could be obtained to construct wind turbines off-shore, any structures placed in the Great Lakes would need to comply with federal, state, and municipal regulations pertaining to the placement of aids to navigation. Specifically, Wis. Stat. § 30.74(2) authorizes the WDNR to develop a system of uniform navigation aids for navigable waters, including the Great Lakes, in cooperation with the United States Coast Guard. Due to increasing interest in off-shore wind projects nationwide, the United States Coast Guard has published guidelines to assist with placing aids to navigation associated with off-shore wind projects.[106]

6.1.3.4 Shoreline Grading - Wis. Stat. § 30.19

An off-shore wind project in the Great Lakes will likely require land-based construction activities to support the off-shore facilities. Depending on their scope, shoreline alterations may require a review and approval from the WDNR under Wis. Stat. § 30.19. For example, permits are required for any project that requires grading more than 10,000 square feet of shoreline on a navigable water body. Before issuing a permit under this section, the WDNR must find that the project will not be detrimental to the public interest, will not cause environmental pollution as defined by Wis. Stat. § 299.01, complies with laws related to platting of land and sanitation, and no material injury will result to adjacent riparian landowners.

6.1.3.5 Evaluation of Wetland and Water Impacts - Section 404 of the Clean Water Act and Wis. Stat. § 281.36

While not specific to off-shore wind projects, any activities that affect wetlands or waters may be subject to additional federal and state regulations. If a proposed project results in the discharge of dredged or fill material into a wetland or water that is determined to be under federal jurisdiction, the USACE may require a permit under § 404 of the Clean Water Act.[107] If a proposed project would disturb a wetland or water that is not subject to federal jurisdiction under the Clean Water Act, the WDNR may still require state water quality certification under Wis. Stat. § 281.36.

[106] These guidelines are available at: http://www.uscg.mil/directives/cim/16000-16999/CIM_16500_7A.pdf.
[107] 33 U.S.C. § 1344.

The USACE cannot issue a permit for the discharge of dredged or fill material into wetlands or waters unless the WDNR certifies under § 401 of the Clean Water Act that the project meets state water quality standards established in Wis. Admin. Code ch. NR 103. To receive water quality certification from the WDNR, project applicants must demonstrate that there are no practicable alternatives that would avoid adverse wetland impacts, that any adverse impacts have been minimized to the extent practicable, and that any remaining impacts will not significantly affect wetland functional values.

6.1.3.6 Water Quality Certification – Section 401 of the Clean Water Act

Before the USACE authorizes an activity that requires a federal permit under § 404 of the Clean Water Act, the WDNR would need to certify that the proposed permit does not violate state water quality standards, which are contained in Wis. Admin. Code chs. NR 100 to 106. The process for determining whether a project meets state water quality standards is established in Wis. Admin. Code ch. NR 299.

6.1.3.7 State Endangered and Threatened Species – Wis. Stat. § 29.604

Before issuing a construction authorization or a certificate of public convenience and necessity, Wis. Stat. § 29.604(6r) requires the PSCW to consult with the WDNR to identify whether the proposed project would have an adverse effect on state endangered or threatened species. If WDNR determines that threatened or endangered species use the proposed project site, it may consult with the PSCW and the project applicant to determine if the construction or operation of the project will have an adverse affect on the identified species. The WDNR may issue a permit authorizing the incidental taking of an endangered or threatened species if it finds that: (1) such a taking will not result in jeopardy to the species or its habitat; and (2) the applicant has submitted a conservation plan and implementing agreement that demonstrates the steps taken to avoid and minimize takings. The WDNR may establish permit conditions that require reporting and monitoring of effects on listed species.

6.1.3.8 Wisconsin Historic Preservation Act – Wis. Stats. §§ 44.30 to 44.39

Wis. Stats. §§ 44.39 and 44.40 require the Wisconsin State Historical Society to keep a register of historic places. State agencies are required to cooperate with the Society to minimize the effects of state actions on designated state historic landmarks and to consider whether any proposed action will have impacts on historic places. These laws would also apply to submerged sites, sites as shipwrecks.

6.1.3.9 Aviation Clearances - Wis. Stats. §§ 114.135(6) and (7)

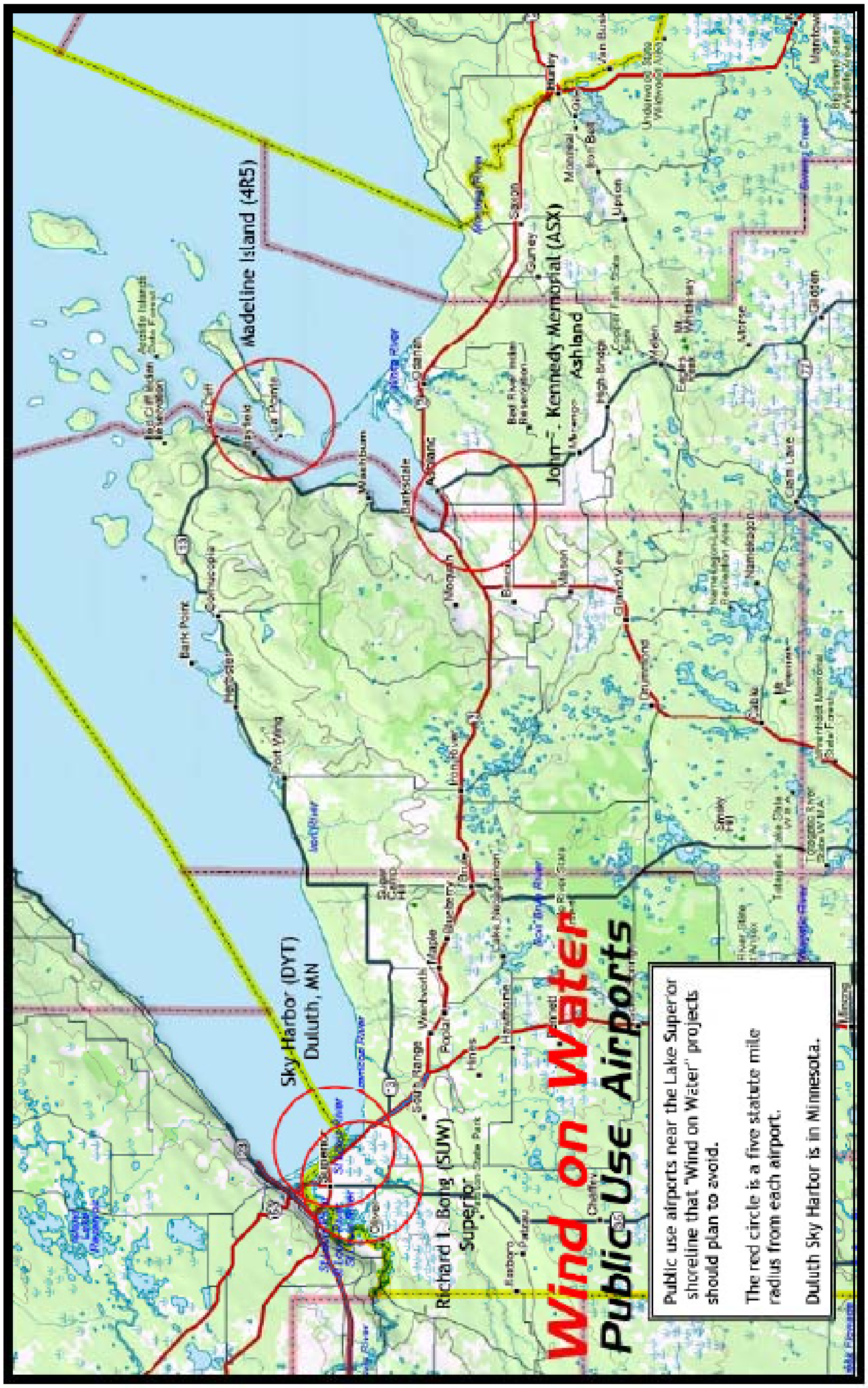
Great Lakes wind projects located near an airport may require a permit from the Wisconsin Department of Transportation (WDOT) depending on the height of the structures. Wis. Stats. §§ 114.135(6) and (7) requires a permit for any structures that are taller than 150 feet if: (1) the structure would be more than 500 feet above the lowest terrain elevation on land or water within one statute mile of the structure's base; or (2) the structure would make a slope ratio of steeper than 40:1 to the nearest point on the nearest runway at the nearest public use airport.

Since these requirements only affect projects in the Great Lakes that are located near public use airports, these permits could be avoided through the selection of appropriate project sites. Public use airports located near Lakes Michigan and Superior are shown in Figures 6.2 and 6.3, respectively.

Figure 6.2: Public Use Airports on Lake Michigan

Source: Wisconsin Department of Transportation (2008)

Figure 6.3: Public Use Airports on Lake Superior



Source: Wisconsin Department of Transportation (2008)

6.1.3.10 Discharge of Pollutants into Lakes Michigan or Superior - Wis. Stat. ch. 283

The construction and operation of an off-shore wind project or associated on-shore facilities may result in the discharge of pollutants to the Great Lakes. Wis. Stat. ch. 283 requires any project that results in a point source discharge of pollutants to the waters of the state to obtain a Wisconsin Pollution Discharge Elimination System permit from the WDNR. In addition, on-shore activities related to a Great Lakes wind project that would individually or cumulatively disturb one acre or more require the landowner to obtain a construction site stormwater discharge permit under Wis. Admin. Code ch. NR 216. These permits currently are available from the WDNR, but in the future some municipalities may administer the stormwater permitting program on behalf of the state. As part of the permitting process, applicants must prepare and implement two distinct plans: an erosion control plan to manage runoff during construction and a post-construction stormwater management plan.

6.1.3.11 Hazardous Spills Law – Wis. Stat. § 292.11

The accidental discharge of a hazardous substance to the environment during construction, operation, or maintenance of a wind turbine would be regulated as a spill under Wis. Stat. § 292.11. Under this law, the WDNR requires responsible parties to report spills and to restore any environmental damage to the extent practicable. Likewise, to the extent any contaminated sediments are encountered during on-shore or off-shore construction activities, care must be taken to not disturb them.

6.1.3.12 Hazardous Waste Management – Wis. Stat. ch. 291

Under Wis. Stat. ch. 291, and Wis. Admin. Code chs. NR 660 to 679, any person who generates a solid waste during construction, operation, maintenance or decommissioning of wind turbines or wave generators and their associated facilities would be required to determine whether that waste is a hazardous waste and must manage it accordingly. Hazardous waste generators are responsible for the cradle-to-grave management of their wastes. In addition, the transportation, storage, treatment and disposal of hazardous waste are each subject to strict environmental standards and require a state license.

6.2 Regulation By Local Units of Government

Local units of governments, including counties, cities, villages, and towns, may have some authority to regulate the development and operation of wind projects in the Great Lakes. In some cases, the extent of their authority may depend on how their boundaries are defined with respect to the Great Lakes and whether structures would be placed within an established pierhead line under Wis. Stat. § 30.13(4). However, Wis. Stat. § 196.491(3)(i), prohibits local ordinances from interfering with the installation or operation of any project that receives a certificate of public convenience and necessity from the PSCW. Similarly, Wis. Stat. § 196.491(2r) prevents local units of government from prohibiting or restricting testing undertaken by an electric utility for the purposes of determining the suitability of a site for the placement of a facility, although the local unit of government may petition the PSCW to impose reasonable restrictions on such activity. As a result, local units of government may be prohibited from placing restrictions on off-shore wind projects in the Great Lakes, regardless of their boundaries or regulatory authorities, if the project receives a certificate of public convenience and necessity from the PSCW.

6.2.1 County and Municipal Boundaries

In general, county and town boundaries extend beyond the ordinary high water mark and are coincident with the state boundary in the Great Lakes. The eastern boundary of the State of Wisconsin is defined by Article II, Section 1 of the Wisconsin Constitution as the middle of the lake "running with the boundary line of the State of Michigan through Lake Michigan. For example, Wis. Stat. § 2.01(4) defines the eastern boundary of Milwaukee County as "the boundary line of this state in Lake Michigan."

The territorial limits of cities and villages with respect to submerged lands in the Great Lakes are determined, in part, by the Public Trust Doctrine, which is codified in Article IX, Sec. 1 of the Wisconsin Constitution. This doctrine recognizes that the use of navigable waterways is protected for both commercial and recreational purposes,[108] which means that the State of Wisconsin holds title to the beds of lakes, ponds and rivers “up to the line of ordinary high-water mark, within the boundaries of the state…”[109] Because the Wisconsin Legislature is primarily responsible for administering the public trust, the ability of a city or village to regulate activities beyond the ordinary high water mark must be authorized by the Legislature and is subject to other state laws.[110]

However, the boundaries of certain cities and villages adjacent to the Great Lakes differ, depending on the purpose for which the boundaries are established. For example, Section 13-01 of the Milwaukee City Charter defines the easterly boundary of "the harbor of Milwaukee" as "Lake Michigan to a distance of one mile from the shore along the east front of said City." However, Section llB-BO-2-d of the City of Milwaukee’s ordinances define the "easterly boundary of the City of Milwaukee and its harbor" as "the center line of Lake Michigan coincident with the easterly boundary of the State of Wisconsin" for the purposes of regulating navigation, activities within the Milwaukee Harbor, swimming and skin diving in Lake Michigan, and littering in Lake Michigan waters.

Further, the Wisconsin Legislature has ceded title to submerged lands through lakebed grants to some municipalities for a specific purpose. For example, the State ceded to the City of Sheboygan all right, title and interest in the lakebed of Lake Michigan lying between the City’s north and south corporate limits out to a distance of 1,700 feet.[111] Similarly, the State ceded submerged lands to the City of Kenosha that is limited to public park purposes. While this may provide some authority for the municipality to influence activities beyond the ordinary high water mark,[112] in general, lakebed grants confer only limited rights to the municipality. The

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[108] See *Muench v. Public Service Comm.*, 261 Wis. 492, 511-512, 53 N.W.2d 514 (1952).
[109] See *State of Wisconsin v. Trudeau*, 139 Wis. 2d 91, 408 N.W.2d 337 (1987).
[110] See *State of Wisconsin v. Village of Lake Delton*, 93 Wis. 2d 78, 286 N.W.2d 622 (Ct. App. 1979).
[111] Chapter. 451, 1947 Laws of Wisconsin.
[112] See *State of Wisconsin v. Village of Lake Delton*, 93 Wis. 2d 78, 286 N.W.2d 622 (Ct. App. 1979).

State of Wisconsin retains the authority and responsibility to enforce the terms of the lakebed grant and to regulate other activities in navigable waters through the WDNR's authority under Wis. Stat. ch. 30.[113]

6.2.2 Wind Access Permits

Wis. Stat. § 66.0403 authorizes local units of government, including counties, cities, villages, and towns, to require wind access permits for the development and operation of wind projects on land that is within their territorial limits, or land that is subject to an extraterritorial zoning ordinance adopted by a city or village under Wis. Stat. § 62.23(7a) unless such land is subject to a zoning ordinance adopted by a county or a town. A local unit of government is required to issue a wind access permit if it determines that:

- the project will not unreasonably interfere with the orderly land use and development plans of the municipality;
- no person has demonstrated plans to build a structure that would create an impermissible interference to the project; and
- the benefits of the project will exceed any burdens.[114]

However, Wis. Stat. § 66.0403(12)(a) restricts the ability of counties, cities, villages, and towns to require a permit before constructing or installing a solar collector or wind energy system, regardless of size. In addition, Wis. Stat. § 66.0401(1) preempts any regulation or restrictions by such municipalities upon all wind energy systems, regardless of size, unless such restrictions:

- preserve or protect the public health or safety;
- do not significantly increase project costs or decrease its efficiency; or
- allow for an alternative system of comparable cost and efficiency.

The question of whether a local unit of government could require a wind access permit for an off-shore wind project under this section depends on whether its boundaries extend into the Great Lakes[115] and whether the PSCW has issued a certificate of public convenience and necessity. Nonetheless, the limitations placed on the ability of municipalities to regulate solar and wind energy systems by Wis. Stat. § 66.0401 are not superseded by the powers granted under Wis. Stat. § 66.0403 or by other municipal zoning and conditional use powers. As a result,

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113 See 78 Opinions of the Attorney General 107.

114 See *Roberts v. Manitowoc County Board of Adjustment*, 2006 WI App 169, 295 Wis. 2d 522, 721 N.W.2d 499

115 The web site http://www.wind-watch.org/documents/wisconsin-wind-ordinances/ compiles wind-related ordinances adopted by local units of government.

a municipality's consideration of an application for a wind access permit must be consistent with the restrictions on local regulation.[116]

6.2.3 Local Aid Payments

While not a regulatory requirement, Wis. Stat. § 79.04 authorizes local units of government that host wind projects sited after January 1, 2004, to collect an annual capacity-based utility aid payment in the amount of $4,000 per MW, provided that the nameplate capacity of the facility is greater than one MW. To the extent that local boundaries extend into the Great Lakes, this law could require that payments be made to local units of governments by the owner of an off-shore wind project.

6.3 Federal Laws

There are numerous federal laws that would need to be considered before constructing a wind project, but the three most significant for an off-shore project in the Great Lakes are the National Environmental Policy Act (NEPA), the Clean Water Act (CWA) and the Rivers and Harbors Act of 1899 (RHA). The USACE would serve as the lead federal agency under NEPA because it has the primary regulatory jurisdiction under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. In addition, permits and approvals may be required under other federal laws regulating interstate commerce, navigation, fish and wildlife, and environmental quality. As a result, significant coordination among the PSCW, WDNR, USACE and other federal agencies would be required during the review of an off-shore wind project.

6.3.1 Section 404 of the Clean Water Act

The construction of a Great Lakes wind project may require approval from the USACE, depending on the scope and nature of the activities associated with constructing off-shore turbines, transmission lines and other facilities. As noted, Section 404 of the Clean Water Act (33 U.S.C. § 1344) authorizes the USACE to issue permits for the discharge of dredged or fill material into the waters of the United States,[117] which includes the Great Lakes. Any activity that results in the discharge of dredged or fill material in a water of the United States would require a Section 404 permit. However, permitting requirements for an off-shore wind project will depend on the type of structures proposed and the construction methods used.

Before the USACE authorizes an activity that requires a permit under Section 404, Section 401 of the Clean Water Act requires that the WDNR certify that the project meets state water quality standards established in Wis. Admin. Code chs. NR 100 to 106, or waive its authority to issue a certification. The process for determining whether a project meets state water quality standards is outlined in Wis. Admin. Code ch. NR 299.

[116] See *State of Wisconsin ex rel. Numrich v. City of Mequon Board of Zoning Appeals*, 2001 WI App 88, 242 Wis. 2d 677, 626 N.W. 2d 366.

[117] "Waters of the United States" are defined at 33 C.F.R. 328.3, and generally include interstate waters, including tributaries, that have been or are currently used in interstate commerce.

6.3.2 Section 10 of the Rivers and Harbors Act of 1899

Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. § 403) authorizes the USACE to issue permits for activities located in the navigable waters of the United States, which include the Great Lakes. The types of activities regulated include: (1) the construction of any structures in, over, or under any navigable water; (2) the excavation from or deposition of material into navigable waters; and (3) any work affecting the course, location, condition, or capacity of navigable waters. The authority of the USACE under Section 10 is broad and includes driven pilings, dredging, filling, building structures, tunneling and boring, and power line construction. As a result, a Great Lakes wind project would require USACE authorization under Section 10 of the Rivers and Harbors Act. In addition, many activities that are regulated under Section 10 of the Rivers and Harbors Act are also regulated under Section 404 of the Clean Water Act.

6.3.3 National Environmental Policy Act of 1969

The National Environmental Policy Act (42 U.S.C § 4321 *et seq.)*, or NEPA, requires that federal agencies involved in a major federal action - such as approving permits or providing funding for a project - that significantly affects the quality of the human environment to consider the environmental effects of the action and provide an opportunity for public involvement in the decision-making process. NEPA also requires an evaluation of alternatives including taking no action and determining the least damaging practicable alternative. Typically, federal agencies prepare an environmental assessment to determine whether a full environmental impact statement (EIS) is needed. Due to the scope of activities necessary to develop a Great Lakes wind project, it is likely that a federal environmental impact statement would be required.

The USACE would likely serve as the lead federal agency for a Great Lakes wind project based on its jurisdiction and authorities under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899. However, 40 C.F.R. § 1501 allows other federal agencies, state agencies, and local governments to participate in the development of the EIS as a joint lead agency or as a cooperating agency. Federally recognized Indian Tribes may also assist with the preparation of the EIS as cooperating agencies. In preparing its EIS, the USACE would need to consider the immediate and cumulative impacts of issuing a permit for a proposed wind project on the Great Lakes, including both the beneficial and adverse effects on fish and wildlife, commercial and recreational uses, air and water quality, cultural and historical resources, and other factors. NEPA also requires that the lead federal agency coordinate its review with cooperating federal agencies that have expertise or jurisdiction under other federal laws. For the purposes of a Great Lakes wind project, these could include but are not limited to: the U.S. Fish and Wildlife Service (USFWS), the United States Coast Guard (USCG), the Federal Aviation Administration (FAA), the U.S. Environmental Protection Agency (USEPA), and the National Oceanic and Atmospheric Administration (NOAA).

Federal Laws Pertaining to Fish and Wildlife

In addition to permits required from the USACE, wind projects in the Great Lakes may be subject to permitting and approval by the USFWS under the Fish and Wildlife Coordination

Act, the Endangered Species Act, the Migratory Bird Treaty Act, and the Bald Eagle Protection Act.

6.3.4.1 Endangered Species Act-16 U.S.C. §§ 1531 to 1544

The purpose of the Endangered Species Act is to protect and recover species listed as threatened or endangered by the USFWS. The Act protects these species and their habitats by prohibiting the taking of listed animals without a permit. The term "taking" is defined to include harassing, harming, pursuing, hunting, shooting, killing, capturing, collecting, or the attempt at such activities. The USFWS has further defined harm to mean any act that kills or injures wildlife, including significant habitat modification or degradation that significantly impairs feeding, breeding, and sheltering. The Act also requires the USFWS service to designate geographic areas that are essential to the conservation of endangered or threatened species as critical habitat.

Section 7 of the Act requires federal agencies to consult with the USFWS to ensure that any action they authorize, implement, or fund will not jeopardize the continued existence of a federally endangered or threatened species or adversely affect critical habitat. Further, Section 9 of the Act requires federal agencies to avoid activities such as issuing permits or otherwise undertaking projects that would result in the destruction or adverse modification of critical habitat.

Individuals, corporations, Indian tribes, states, and local governments that want to develop property that is used by a listed species can apply to the USFWS for a permit under Section 10 of the Act. If it determines that such a taking would not jeopardize the species, the USFWS may issue a permit for an "incidental taking" of an endangered or threatened species that would occur as a result of an otherwise legal activity, such as the construction or operation of wind turbines. In addition, the project applicant must submit a habitat conservation plan that specifies:

- the impacts to the species that will likely result from such taking;
- the steps the applicant will take to minimize and mitigate such impacts;
- the funding that will be available to implement such steps;
- alternative actions considered by the applicant and the reasons why such alternatives were not selected; and
- other measures that the USFWS may require.

6.3.4.2 Migratory Bird Treaty Act – 16 U.S.C §§ 703 to 712

The Migratory Bird Treaty Act prohibits the taking of migratory birds listed at 50 C.F.R Part 10.13 without federal authorization. Authorization may include compliance with specific regulations, such as hunting seasons, or the issuance of permits by the USFWS. Under 50 C.F.R.

Parts 20 and 21, the USFWS may issue permit for the intentional taking of migratory species to qualified applicants for the following types of activities: falconry, raptor propagation, scientific collection, special purposes (such as rehabilitation, educational, migratory game bird propagation, and salvage), control of depredating birds, taxidermy, and waterfowl sale and disposal. Unlike the Endangered Species Act, the USFWS does not have regulations that authorize permits for the incidental take of migratory bird species. Instead, the USFWS relies on informal cooperation and its enforcement discretion to address projects that result in incidental takings. The risk of off-shore wind turbines in the Great Lakes to migratory birds is unknown, but it is likely that some coordination with the USFWS would be required for such projects.

6.3.4.3 Fish and Wildlife Coordination Act – 16 U.S.C. §§ 661 to 667e

Federal agencies that construct, license, or permit water resource development projects are required to consult with the USFWS and the WDNR to determine the effects of such projects on fish and wildlife resources and to identify measures for mitigating any adverse impacts. Due to increasing interest in the development of wind projects nationwide, the USFWS has issued voluntary interim guidelines to assist federal agencies in avoiding and minimizing wildlife impacts related to terrestrial wind projects.[118] These guidelines are intended to assist USFWS personnel in providing technical assistance on: (1) proper evaluation of potential wind sites; (2) proper location and design of turbines and associated structures within selected sites; and (3) pre- and post-construction research and monitoring to identify and assess impacts to wildlife. The USFWS intends to issue similar guidance for marine and Great Lakes wind turbine installations.

6.3.4.4 Bald Eagle Protection Act - 16 U.S.C. § 668 *et seq.*

The Bald Eagle Protection Act prohibits the taking, possession, transport, and commerce of bald and golden eagles, with limited exceptions. The USFWS issues permits to take, possess, and transport bald and golden eagles only for scientific, educational, and Indian religious purposes, depredation, and falconry under 50 C.F.R. Parts 13 and 22. The risk of off-shore wind turbines in the Great Lakes to bald eagles is unknown, but some coordination with the USFWS may be required for such projects.

6.3.5 Other Federal Laws and Requirements

Depending on the location chosen for a Great Lakes wind project, and the types of activities necessary for its construction and operation, other federal laws may need to be considered. However, the barriers presented by these laws could likely be addressed through site selection, project planning, and turbine operation.

6.3.5.1 Coastal Zone Management Act - 16 U.S.C. §§ 1451 to 1465

The Coastal Zone Management Act (CZMA) establishes a voluntary federal-state partnership program to encourage coastal states, including those on the Great Lakes, to develop comprehensive programs to manage competing coastal uses and impacts. The CZMA does not

[118] See the interim voluntary guidelines to avoid and minimize wildlife impacts from wind turbines (68 Fed. Reg. 132, pages 41174-41175, July 10, 2003), available at http://www.fws.gov/habitatconservation/windpower/.

establish new federal regulatory requirements; rather it emphasizes coordination and the primacy of state decision-making. Section 307 of the CZMA (16 U.S.C § 1456), also known as the federal consistency provision, is the cornerstone of the program and provides the primary incentive for states to participate.

Pursuant to Section 307, any federal agency activity that has a reasonably foreseeable effect on the coastal zone must be consistent, to the maximum extent practicable, with the enforceable policies of a state's federally approved coastal management program. Federal agency activities can include any projects performed by a federal agency or contractor for the benefit of a federal agency, as well as federal grants, permits, approvals, or license activities. States with approved coastal management programs have the opportunity to review, and in many cases prevent, federal activities that are inconsistent with their programs.

The Wisconsin Coastal Management Program (WCMP) is overseen by the Coastal Management Council, which was created by gubernatorial executive order and is staffed by the Department of Administration. The Council, with its staff, is ultimately responsible for coordinating state consistency reviews and notifying federal agencies of state concurrence or objection under Section 307. While the program incorporates existing state laws and administrative rules into its enforceable policies, other state agencies retain their existing authorities. As a result, the program provides a coordinative, rather than regulatory role.

Wisconsin's coastal zone is defined as the state boundary on the waterward side of the Great Lakes and the inland boundary of the 15 counties adjacent to Lake Michigan and Lake Superior. Any wind turbine project included in this defined area that receives federal funding or that requires federal authorization, approval, or permits would trigger a Section 307 state consistency review. However, off-shore wind projects that meet the conditions for approval under all other state and federal laws would likely be consistent with the enforceable policies of Wisconsin's program.

6.3.5.2 National Historic Preservation Act 16 U.S.C. § 470 *et seq*.

Section 106 of the National Historic Preservation Act requires that federal agencies consider the effects on historic cultural resources of any project that is federally funded, licensed, or permitted, or that occurs on or within federal or tribal lands and waters. In general, any site or structure that is more than 50 years old is considered historic, whether it is recorded as such or not. The Act functions like the National Environmental Policy Act (NEPA), which requires the lead federal agency to make a determination of the presence of historic items or sites and to evaluate the effects of the project on such sites. Because there could be historically significant shipwrecks or other cultural resources located off-shore in the Great Lakes, an analysis under this law would likely be required.

6.3.5.3 Shipping, Coastwise Trade, and Related Laws – 46 U.S.C § 101 et seq.

Title 46 of the United States Code regulates shipping and related activities in the coastal waters of the United States, including the Great Lakes. Its primary purpose is to protect United States shipping interests. In general, Title 46 requires that ships carrying merchandise or passengers in U.S. territorial waters or between U.S. ports be U.S. built, owned, and documented by the United States Coast Guard with a certification known as a "coastwise endorsement." Waivers can be granted by statute only for national defense or for other purposes by an Act of Congress. The availability of domestic vessels is not a consideration in granting waivers. Originally enacted as the Merchant Marine Act of 1920, Title 46 was recodified by Public Law 109-304.

The restrictions on coastwise trade found in 46 U.S.C. § 55102 (commonly known as the "Jones Act") would likely apply to any vessels used in the construction, operation, or maintenance of a wind project on the Great Lakes, regardless of its size. In addition, Title 46 contains other provisions regulating the vessels used for passenger services (46 U.S.C. § 55103), dredging (46 U.S.C. § 55109), and towing (46 U.S.C. § 55111) that would be applicable to the Great Lakes. Currently, there are no vessels operating in the Great Lakes that are suitable for constructing and maintaining an off-shore wind project, and it is not known whether there are existing vessels elsewhere that are capable of receiving a United States Coast Guard coastwise endorsement.

6.3.5.4 Federal Aviation Administration Airspace Study

Under 14 C.F.R. Part 77, a Federal Aviation Administration (FAA) airspace study is required before constructing certain types of projects, including any structure taller than 200 feet. The purpose of these studies is to determine whether the proposed construction would be a hazard to air transportation. While the Federal Aviation Administration is not a permitting authority, it could withhold future federal airport improvement grants or recover past grants if it determines that a project would be a hazard to air navigation or cause deterioration in capability, yet the responsible regulatory authorities allow the project to be constructed. Because wind projects in the Great Lakes may raise concerns about airspace safety and radar interference, an airspace study may be required prior to construction. Nonetheless, such aviation concerns could be minimized by avoiding the siting of such projects near public use airports along the Great Lakes.

6.3.5.5 Areas Reserved for Military Purposes

There are several areas in the Great Lakes that are reserved for military purposes, or that have been proposed for such purposes. The development of wind projects would likely be considered an incompatible use within these specially designated areas.

Specifically, pursuant to 33 C.F.R § 334.845, the United States Department of Defense has established a danger zone in the waters of Lake Michigan off-shore from Manitowoc and Sheboygan Counties. The Wisconsin Air National Guard utilizes this area for periodic military training exercises which includes, but is not limited to, inert air-to-air and air-to-surface delivery, defense countermeasures training, and sonar buoy drops. Navigation and other activities are restricted or limited during specific, infrequent periods when military exercises are being conducted in this area.

Similarly, the United States Coast Guard has established safety and security zones under 33 C.F.R. Part 165 where navigation and other activities may be restricted. Security zones are intended to protect critical infrastructure, such as power plants and harbors, from destruction, loss, or injury from sabotage or other subversive acts. Safety zones are areas where access or navigation may be restricted for environmental or safety reasons. Currently, The United States Coast Guard has designated security zones near the Kewaunee and Point Beach nuclear power plants and safety zones at the Milwaukee Harbor and at the Duluth/Interlake Tar remediation site in the St. Louis River estuary.

In 2006, the United States Coast Guard proposed establishing an additional 34 permanent safety zones in the Great Lakes, including several in the Wisconsin waters of Lake Superior and Lake Michigan. These safety zones were intended to serve as training areas for United States Coast Guard personnel to conduct live-fire training exercises with small caliber weapons. Due to the extent of public concern, the United States Coast Guard withdrew its proposal.

6.3.5.6 Federally Designated Wilderness Areas – 16 U.S.C. §§ 1131 to 1136

The National Wilderness Preservation System consists of federally owned lands designated by Congress as wilderness areas under 16 U.S.C. § 1131(2)(a). These lands are managed primarily for their wilderness qualities; most commercial uses and development are strictly prohibited. The Gaylord A. Nelson Apostle Islands National Lakeshore Wilderness Area on Lake Superior was designated by P.L. 108-447. While the designation did not include any of the waters of Lake Superior, it is likely that nearby off-shore wind projects would be inconsistent with the wilderness designation.

Comprehensive Environmental Response, Compensation, and Liability Act - 42 U.S.C. § 9601 *et seq*. and the Resource Conservation and Recovery Act - 42 U.S.C. § 6901 *et seq.*

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), any discharge of a hazardous substance from an off-shore wind turbine would result in liability for cleaning up or remediating the waste. Moreover, the generation, transportation, storage, treatment and disposal of any hazardous waste that results from the construction, operation, maintenance, or decommissioning of wind turbines would be subject to strict environmental standards under the Resource Conservation and Recovery Act (RCRA) and require a state license. The WDNR is authorized by U.S. EPA to administer most of RCRA in Wisconsin, but to the extent that the State is not authorized to administer portions of RCRA, or if Wisconsin's authorization is not up to date with federal regulatory changes, such activities also are subject to direct regulation by U.S. EPA and must also comply with federal standards, including U.S. EPA permit requirements. Both civil and criminal penalties apply to violations of federal hazardous waste requirements.

6.3.5.8 Clean Water Act Petroleum and Hazardous Substance Spill Law 33 U.S.C. § 1321

The Clean Water Act generally prohibits the discharge of oil and hazardous substances into coastal or ocean waters except where permitted under the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships. Section 311 of the Act establishes a program for preventing, preparing for, and responding to oil spills that occur in navigable waters of the United States. In general, the United States Coast Guard is responsible for investigating and responding to the discharge of oil and hazardous substances into coastal or ocean waters. However, facilities are required to prepare spill prevention, control, and countermeasure plans according to rules promulgated by the U.S. EPA at 40 C.F.R Part 112. Depending on the volume of oil stored in gear boxes and other turbine components, wind projects in the Great Lakes will likely need to develop a plan.

6.3.5.9 Emergency Planning and Community Right to Know Act 42 U.S.C. § 11001 to 11050

The purpose of the Emergency Planning and Community Right to Know Act (EPCRA) is to provide the public with information about hazardous chemicals in their communities to enhance community awareness and facilitate development of state and local emergency response plans. Under this Act, facilities may be required to report the storage, use, and release of certain hazardous chemicals, and to participate in emergency response planning. The requirement to participate in planning applies to any facility with any extremely hazardous substance on site that is greater than the relevant threshold planning quantities. The reporting requirements depend on thresholds for specific chemicals, as set out in regulations promulgated by U.S. EPA at 40 C.F.R. Part 370. Off-shore wind projects would likely be subject to this law.

6.3.6 Tribal Laws and Consultation

There are eleven federally-recognized Indian Tribes with reservation lands in Wisconsin.[119] Six of these Tribes are Chippewa Bands that have court recognized off-reservation treaty rights to harvest many natural resources in Wisconsin.[120] Of these, only the reservations

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[119] These include: the Bad River Band of the Lake Superior Tribe of Chippewa Indians, The Red Cliff Band of Lake Superior Chippewa Indians, The Lac Courte Oreilles Band of Lake Superior Chippewa Indians, The Lac du Flambeau Band of Lake Superior Chippewa Indians, The St. Croix Chippewa Tribe of Wisconsin, The Sokaogon Chippewa Community of the Mole Lake Band, The Forest County Potawatomi Community, The Ho-Chunk Nation, The Menominee Indian Tribe of Wisconsin, The Oneida Nation of Wisconsin, and The Stockbridge-Munsee Community.

[120] *See* Treaty of 1837, 7 Stat. 536; Treaty of 1842, 7 Stat. 591; Treaty of 1854, 10 Stat. 1109; *Lac Courte Oreilles v. Voigt* (*LCO I*), 700 F.2d 341 (7th Cir. 1983), *cert. denied*, 464 U.S. 805 (1983); *Lac Courte Oreilles v. State of Wisconsin* (*LCO III*), 653 F.Supp. 1420 (W.D. Wis. 1987); *Lac Courte Oreilles v. State of Wisconsin* (*LCO IV*), 668 F.Supp. 1233 (W.D. Wis. 1987); *Lac Courte Oreilles v. State of Wisconsin* (*LCO V*), 686 F.Supp. 226 (W.D. Wis. 1988); *Lac Courte Oreilles v. State of Wisconsin* (*LCO VI*), 707 F.Supp. 1034 (W.D. Wis. 1989); *Lac Courte Oreilles v. State of Wisconsin* (*LCO VII*), 740 F.Supp 1400 (W.D. Wis. 1990); *Lac Courte Oreilles v. State of Wisconsin* (*LCO VIII*), 749 F.Supp. 913 (W.D. Wis. 1990); *Lac Courte Oreilles v. State of Wisconsin* (*LCO IX*), 758 F.Supp. 1262 (W.D. Wis. 1991); *Lac Courte Oreilles v. State of Wisconsin* (*LCO X*), 775 F.Supp. 321 (W.D. Wis. 1991); *State v. Gurnoe,* 53 Wis. 2d 390, 192 N.W.2d 892 (1972).

of the Bad River and Red Cliff Bands are located on the shores of Lake Superior. None are located on Lake Michigan. Of the five other Tribes, only the Menominee Indian Tribe has ever asserted a claim of such a right, but the federal courts ultimately determined that the relevant treaties do not provide it.[121] No evidence could be found to suggest that Wisconsin's four other tribes have asserted, nor has any court determined, that they possess any treaty-based or aboriginal possession rights to fish on the Great Lakes.[122]

Nonetheless, Wisconsin's Indian Tribes have important rights and interests at stake in the decisions and regulatory processes regarding the development of wind power generation on the Great Lakes. In areas outside of reservation boundaries, including the waters of Wisconsin's Great Lakes, tribes might not possess regulatory authority but the treaty-reserved use rights some tribes possess provide them with legally protectable interests that state and federal agencies must consider. As a result, when state and federal agencies carry out their statutory responsibilities relevant to wind power development, they must do so in a manner that honors the terms and purposes of the relevant treaties,[123] and they need to acknowledge in carrying out their "fiduciary obligation of managing the natural resources within the [treaty] ceded territory for the benefit of current and future users" that their management options may be narrowed to a "significant degree" by a tribe's treaty rights. *LCO VI,* 707 F.Supp. at 1060. In any event, whether because of statutory obligations or policy choices, and regardless of the substantive legal issues involved, state and federal agencies would be well-advised to consult and attempt to achieve consensus with affected tribes on a government-to-government basis regarding any decision that may affect their treaty or other tribal rights.

6.3.7 Lake Bed Ownership

By operation of the Equal Footing Doctrine, Wisconsin acquired title to the beds of all navigable waters within its borders at statehood in 1848.[124] With one exception (the 1838 Oneida Reservation, which does not border on or encompass any part of Lake Michigan or Lake Superior), all Indian reservations in Wisconsin were established after statehood. It would appear,

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[121] The Menominee Indian Tribe of Wisconsin unsuccessfully sought a judicial declaration that its members had both treaty-based and "aboriginal possession" rights to fish the waters of Green Bay and Lake Michigan. *See Menominee Indian Tribe of Wisconsin v. Thompson*, 943 F.Supp. 999, 1016 (W.D.Wis. 1996), *aff'd, Menominee Indian Tribe of Wisconsin v. Thompson*, 161 F.3d 449, 459, 462 (7th Cir. 1998). The courts rejected the claimed rights under both legal theories.

[122] There are, however, Michigan Bands of Indians with court-recognized rights under an 1836 treaty to harvest fish in certain areas of Lakes Michigan and Superior, but the consent decree governing that Tribal harvest (available at: http://www.1836cora.org/pdf/2000consentdecree.pdf) appears not to include any Wisconsin waters of either lake.

[123] *See, e.g., Northwest Sea Farms v. U.S. Army Corps of Engineers*, 931 F.Supp. 1515, 1520 (W.D. Wash. 1996) ("responsibility to ensure that Indian treaty rights are given full effect"), citing *Seminole Nation v. United States*, 316 U.S. 286, 296-97 (1942).

[124] The Equal Footing Doctrine, embedded in U.S. Const. art. IV, § 3, is a fundamental principle governing the sovereignty of states upon admission to the union. "The right of . . . every . . . new state to exercise all the powers of government, which belong to and may be exercised by the original states of the union, must be admitted, and remain unquestioned . . . ." *Pollard v. Hagan*, 44 U.S. 212, 224 (1845). Included in the sovereignty possessed by states is the "absolute right to all their navigable waters, and the soils under them, for their own common use, subject only to the rights since surrendered by the constitution . . . ." *Martin v. Waddell's Lessee*, 41 U.S. 367, 410 (1842). *See also Montana v. United States*, 450 U.S. 544, 551 (1981); *Shively v. Bowlby*, 152 U.S. 1, 57 (1894). Although the Equal Footing Doctrine applies automatically whenever a state enters the Union, the Wisconsin Enabling Act of 1846, 9 Stat. 56, expressly refers to it. *State of Wisconsin v. Baker*, 698 F.2d 1323, 1333 (7th Cir. 1983).

therefore, that there would be no need to obtain a lease for or a deed to any lake bed property from any Wisconsin Tribes before wind power facilities might be developed on the Great Lakes.[125]

6.3.8 Tribal Off-Reservation, Treaty-Based Usufructuary Rights on the Great Lakes.

6.3.8.1 Chippewa Treaty Use Rights on Lake Superior

The 1854 Treaty with the Chippewa Tribes which created the Red Cliff and Bad River reservations has been construed to provide by implication for a tribal right to harvest fish - a form of "usufructuary right"[126] - from Lake Superior. *State v. Gurnoe*, 53 Wis. 2d 390, 192 N.W.2d 892 (1972). The precise extent of those Lake Superior use rights has never been litigated, but instead has been the subject of a series of detailed, ten-year long agreements between the State of Wisconsin and (collectively) the Red Cliff and Bad River Chippewa Bands. Those agreements provide, among other things, for tribal commercial fishing on vast expanses of Lake Superior.

The 1842 Treaty with the Chippewa Tribes also deals with Lake Superior. In that treaty, the Chippewa ceded to the United States all of the portion of Lake Superior that is now located in Wisconsin. While not specifically litigated,[127] the 1842 treaty signatory tribes would likely claim fishing rights in Lake Superior. These include the six Wisconsin Chippewa tribes - Bad River, Lac Courte Oreilles, Lac du Flambeau, Red Cliff, St. Croix and the Sokaogon Chippewa Community - as well as a number of Chippewa tribes located in Minnesota and Michigan's Upper Peninsula. Presently, other than Bad River and Red Cliff, none of these tribes engage in commercial fishing in Wisconsin waters of Lake Superior, but their tribal members are known to partake in angling.

In addition, as determined in the *Lac Courte Band v. State of Wisconsin* case, these tribes also retain fishing rights in tributaries of Lake Superior and Lake Michigan, as well as hunting, trapping and gathering rights on public lands within the lakes' respective basins. Thus, the tribal use rights affirmed in that case should also be considered in relation to the land-based elements of any water-based power generation development.

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[125] The 1854 (*i.e.*, post-statehood) treaty creating the Bad River reservation on Lake Superior includes much or all of the vast Kakagon Sloughs. Though these wetlands *may* include some land connected to and lying below the elevation of the ordinary high-water mark (*i.e.*, part of the bed) of Lake Superior, it is highly unlikely that anyone would propose to develop a wind power facility in the Kakagon Sloughs. Therefore, this report does not examine whether the reservation boundaries include such lake bed lands or engage in a legal analysis of the federal government's authority post-statehood to divest a state of title to lake beds for the purpose of creating an Indian reservation.

[126] Although the *Gurnoe* case did not address tribal harvest rights on Lake Superior, the seminal court decision on the general scope of Chippewa treaty rights described the "usufructuary right" as including the right to harvest: " . . . those forms of animal life, fish, vegetation and so on that [the Chippewa] utilized at treaty time . . . ." *Lac Courte Oreilles Indians v. State of Wis.*, 775 F.Supp. 321, 322 (W.D.Wis. 1991).

[127] In the seventeen-year long federal Wisconsin Chippewa Treaty rights case, the parties agreed early on not to litigate the issue of tribal use of Lake Superior. *See Lac Courte Oreilles Indians,* 775 F.Supp. at 324 (referring to docket item number R. 330).

6.3.8.2 Implications of Chippewa Treaty Use Rights

When the subject of which sovereign - the State of Wisconsin or the Chippewa Tribes - had the resource management prerogative on inland waters and lands where the Chippewa had treaty-based use rights, the federal court ruled: "The state . . . will continue to bear the responsibility and authority for the management of all of the natural resources of the state except as provided herein." *Lac Courte Oreilles Indians*, 775 F.Supp. at 323. However, the court also held that the state's management options are narrowed to a "significant degree" by the tribes' treaty rights. *Lac Courte Oreilles Band of Lake Superior Chippewa Indians v. State of Wisconsin (LCO VI)*, 707 F.Supp. 1034, 1060 (W.D. Wis. 1989). While not binding precedent, these holdings may well be persuasive legal authority should a similar management prerogative issue arise regarding natural resources subject to tribal use rights in Lake Superior. Hence, while the existence of treaty use rights in Lake Superior, standing alone, does not make the Chippewa Tribes the ultimate managers of that resource, Chippewa treaty use rights cannot and should not be ignored in the process of developing wind power on the Great Lakes. Furthermore, if sufficient and meaningful consultation by both state and federal regulators to obtain tribal concurrence for such developments takes place, the likelihood of litigation involving resource management prerogative issues should be minimized.

Having the management prerogative does not mean that whatever use rights the Chippewa may have in Lake Superior may be ignored by the State in its development of wind power or other resources. Some courts have suggested that off-reservation development by non-members which has an *intentionally* discriminatory effect on tribal use rights may be enjoined. *See, e.g., Nez Perce Tribe v. Idaho Power Co.*, 847 F.Supp. 791, 809 (D.Idaho 1994) (treaty use rights not protected from degradation "caused by development which is not part of a pattern of discrimination against Indian treaty [use rights]").

Related to this issue is the question of whether the existence of an off-reservation treaty use right obliges the state and federal governments to protect the off-reservation resource from degradation associated with things like "the encroachment of industry, commerce and residential development." *Menominee Indian Tribe of Wisconsin v. Thompson*, 922 F.Supp. 184, 215 (W.D.Wis. 1996). As Judge Crabb noted in that case, the concept of a treaty-based "environmental servitude," as the argument has sometimes been called, "has not fared well in the courts." *Id.* at 215-16. The courts have generally concluded that off-reservation treaty harvest rights are subject to changing conditions, that they are an "adaptive entitlement that is not the equivalent of an immutable property right." *Skokomish Indian Tribe v. United States*, 332 F.3d 551, 558 (9th Cir. 2003) (citing *United States v. Winans*, 198 U.S. 371, 381, 25 S.Ct. 662, 49 L.Ed. 1089 (1905)). It may be, of course, that the Tribes have a different view of the law on this subject and that the issue may be raised by a Tribe some day in a manner the courts find more compelling than in these previous cases. On the basis of the well established legal proposition that treaty-reserved use rights "are too fundamental to be easily cast aside." *United States v. Dion*, 476 U.S. 734, 739 (1986), the Tribes may contend there is a point at which a particular action may be enjoined as improperly interfering with treaty off-reservation use rights.[128] Of

[128] *See, e.g.¸ Muckleshoot Indian Tribe v. Hall,* 698 F.Supp. 1504, 1523 (W.D. Wash. 1988) (granting injunction against the construction of a marina in consideration of the effect upon Indian treaty fishing rights); *Northwest Sea*

course the potential for this issue to arise will be highly dependent on the particular facts involved in the matter and the nature and extent of the alleged interference and any mitigation options.[129] Presumably the State would not authorize a project which would have significant detrimental effects on fisheries or other resources anyway and the State would consult with and attempt to obtain tribal concurrence for all major development projects in these areas.[130] For those reasons the State believes it is unlikely this issue ever will be litigated in the context of wind power development on the Great Lakes.

From the State's perspective the current law is that the existence of treaty-based use rights on Lake Superior does not provide tribal veto authority over projects in the Great Lakes, even if the development may change the face of the off-reservation environment. From a tribal perspective, however, although state and federal agencies may exercise their statutory responsibilities, they cannot exercise their authority in a way that would directly or constructively abrogate or infringe upon treaty-reserved use rights, whether through direct regulation of the time, manner or place of treaty rights exercise or through adverse impacts on the natural resources and habitats underlying those rights.

6.3.9 Other Tribal Approvals

6.3.9.1 Clean Water Act "Treatment-as-a-State"

In 1987, Congress added to the federal Clean Water Act a provision authorizing the United States Environmental Protection Agency to treat Indian tribes as states (often referred to as "TAS" authority) in certain respects under the Act - including the ability to establish water quality standards and to certify compliance with such standards. 33 U.S.C.A. § 1377(e). As implemented, a Tribe could obtain TAS authority to administer a water quality standards program for waters "within the borders of the Indian reservation. . . ." 40 C.F.R. § 131.8(a)(1)-(4) (2007). No evidence could be found that any Wisconsin Tribe has applied for TAS authority under the Clean Water Act for any portion of the Great Lakes. In theory, however, if water quality within a reservation of a Tribe with TAS authority were threatened with contamination by off-reservation water-polluting activity regulated under a state or federal wastewater discharge permit, the Tribe could object to the other government's issuance of a discharge permit and thereby effectively veto it. It is unclear whether such veto authority is limited to rivers where an upstream/off-reservation source of pollution threatens on-reservation tribal water quality. *See, e.g., City of Albuquerque v. Browner*, 97 F.3d

Farms v. U.S. Army Corps of Engineers, 931 F.Supp. 1515 (W.D. Wash. 1996) (enjoining the placement of salmon pens on a tribal usual and accustomed fishing ground).

[129] *See, e.g., United States v. Washington*, 759 F.2d 1353, 1357 (9th Cir. 1985) ("the legal standards that will govern the State's precise obligations and duties under the treaty with respect to the myriad of State actions that may affect the environment of the treaty area will depend for their definition and articulation upon concrete facts which underlies a dispute in a particular case").

[130] Tribal consultation requirements are discussed more specifically in other sections of this report. As regarding the exercise of the State's management prerogative in the context of the *Lac Courte Oreille v. State of Wisconsin* case, the parties agreed to a number of processes to facilitate consultation and coordination. *See, e.g.*, Stipulation for Wild Rice Trial, at 9 (Docket 1222) (state agrees to consult with plaintiff tribes "before the issuance of any permit which is required to be obtained from the State regarding any activity which may reasonably be expected to directly affect the abundance or habitat of wild rice in the ceded territory…. "). As indicated above, the *LCO* case, strictly speaking, does not apply to Lake Superior, that stipulation suggests an approach the parties may decide to apply to this situation as well.

415 (10th Cir. 1996). Whether any kind of activity associated with the installation of wind turbines might ever have such a polluting effect, and whether any Wisconsin tribe will ever get TAS approval for a water quality standards program involving any part of the Great Lakes, seems very speculative. In sum, it does not appear that the federal Clean Water Act TAS program now requires any regulatory approval from any Tribe for an off-shore wind project.

6.3.9.2 Clean Air Act "Treatment-as-a-State"

The federal Clean Air Act also has a Tribal TAS program. *See* 40 C.F.R. Part 49. It does not appear from the Code of Federal Regulations, however, that any Wisconsin Tribes have received authorization to operate on-reservation Clean Air Act TAS programs. *See* 40 C.F.R. Subpart H. This is not to say that air pollution on Wisconsin Indian reservations is unregulated; in the absence of an approved Tribal program EPA Region V asserts it has authority to administer the Clean Air Act on Indian reservations under its "Direct Implementation" program.[131] Since wind power generation is not expected to result in much - or even any - emissions of pollutants into the air, and the fact that no Wisconsin Tribe now operates a program, it unlikely that an off-shore wind project will trigger the need for any Tribal Clean Air Act program regulatory approvals.

6.3.10 Tribal Consultations Under Other Treaties and Statutes

The regulatory regime becomes significantly more complex if any aspect of on-shore infrastructure, such as transmission lines, associated with water-based wind power development is proposed to be constructed within tribal reservation boundaries or on any land owned by a tribe, held in trust by the United States for the benefit of a tribe or individual tribal members. As a general rule, tribal regulatory and land use powers within reservation boundaries are more extensive than in the off-reservation context. Moreover, once tribal trust lands become involved, federal authority might be implicated, perhaps including the need to gain federal approval of easements across such lands. Given the complexities involved and the likelihood that on-reservation wind power development would be pursued jointly with the local tribe, discussion of the more intricate and nuanced on-reservation legal issues should be reserved until specific circumstances require it.

Aside from regulatory authority issues, tribes maintain that state and federal agencies have the duty to consult with them on regulatory decisions that will affect tribal lands, rights or interests, including off-reservation use rights. Consultation requirements, as also discussed in other sections, can be found in statutes,[132] case law,[133] executive orders,[134] and agency policies.[135]

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[131] EPA Region V, headquartered in Chicago, Illinois, includes the State of Wisconsin and its eleven Indian tribes and bands. See http://www.epa.gov/region5/air/tribes/.

[132] *See, e.g.,* discussion of National Historic Preservation Act.

[133] *See, e.g.,* cases regarding federal treaty obligations and the trust responsibility such as *Cherokee Nation v. Georgia*, 30 U.S. (5 Pet.) 1 (1831); *United States v. Kagama*, 118 U.S. 375, 382-384 (1886); *Tullee v. Washington*, (315 U.S. 681 (1942); *Nance v. EPA*, 645 F.2d 701 (9th Cir.), *cert. denied*, 454 U.S. 1081 (1981) (trust responsibility extends to all branches of the federal government); *Mille Lacs Band v. Minnesota*, 861 F.Supp. 784, 826 (D. Minn. 1994) (federal officials must "act as fiduciaries when dealing with tribes and must consider and protect the interest of their Indian wards"). *See also Lac Courte Oreilles Band v. State of Wisconsin,* regarding consultation requirements.

Generally speaking, the tribes take the position that these consultations should be carried out in the context of a government-to-government relationship based on the premise of good faith and fair dealings. They should facilitate an extensive understanding of the tribal rights and interests involved, the impacts of the proposed actions, and their alternatives on those rights and interests, and the tribal view of what should be done. Unless specifically provided in the relevant statute or ruling, a consultation requirement generally does not override the power of any agency to make decisions within the bounds of its particular statutory authority. Of course, such decisions are subject to challenge or appeal as the relevant statutory or case law otherwise provides.

6.4 International Treaties and Agreements Pertaining to the Great Lakes

There are a number of interstate and international agreements and treaties pertaining to the Great Lakes that establish processes for notification, coordination, and collaboration among various government entities, including states, provinces, tribal governments and the governments of the United States and Canada. In general, these agreements are focused on specific management concerns and do not contain self-enforcing regulatory requirements. Nonetheless, the State of Wisconsin may have an obligation to notify and coordinate with other governments under these agreements. However, the WDNR believes that it is unlikely that these agreements would affect the development of an off-shore wind project except under special circumstances.

Some of the agreements that may be relevant to wind projects in the Great Lakes include:

- The Boundary Waters Treaty of 1909 between the United States and Great Britain establishes a six member Commission to oversee the water level and system flow management of all boundary waters including the Great Lakes. Any activity which could impact the flow regimes established by the Commission must be evaluated and approved by the Commission before either Canada or the United States allow a project to proceed. This would only be applicable to projects on Lake Superior, because Lake Michigan is entirely contained within the United States.

- The Water Quality Agreement between Canada and the United States establishes management goals, processes to achieve these goals, and a venue for involvement by the provinces, the states, the two federal governments, and the tribes. While the Agreement

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[134] *See, e.g.,* Presidential Exec. Order No. 13,084, 63 Fed. Reg. 27,655 (1998) and Presidential Memorandum entitled "Government-to-Government Relations with Native American Tribal Governments," 59 Fed. Reg. 22,951 (April 29, 1994); Wisconsin Governor Doyle Executive Order #39 (February 27, 2004) (directing cabinet agencies to recognize the unique government-to-government relationship between the State of Wisconsin and Indian Tribes and to consult with tribal governments when state action or proposed action is anticipated to directly affect an Indian Tribe or its members). The Wisconsin Public Service Commission, however, is not a cabinet agency.

[135] *See, e.g.*, Environmental Protection Agency, *EPA Policy for the Administration of Environmental Programs on Indian Reservations*, Nov. 8, 1984; Army Corps of Engineers, Policy Guidance Letter No. 57: *Indian Sovereignty and Government-to-Government Relations With Indian Tribes*, February 18, 1998; US Fish and Wildlife Service, *The Native American Policy of the U.S. Fish and Wildlife Service*, June 28, 1994; State of Wisconsin, Executive Order #39, *Relating to an Affirmation of the Government-to-Government Relationship Between the State of Wisconsin and Indian Tribal Governments Located Within the State of Wisconsin*, February 27, 2004; State of Wisconsin, Department of Natural Resources, *Policy Regarding Consultation with Wisconsin's Indian Tribes*, June 28, 2005.

calls for the establishment of lake wide management plans for both Lake Michigan and Lake Superior, these plans would not be expected to be relevant to the development of wind projects in the Great Lakes unless they would have an effect on water quality.

- The conventions which created the Great Lakes Fishery Commission and the Great Lakes Basin Compact, which created the Great Lakes Commission. These establish intergovernmental relationships and protocols that provide the opportunity for consultation on certain activities. For example, the WDNR and other state and provincial natural resource agencies have agreed to provide the opportunity for consultation for any project in a Great Lake that would affect fish populations.

6.5 Permitting and Consultation Processes

The application, review, and approval process for a wind project in the Great Lakes will be complicated and require input from many state and federal agencies. This section provides an overview of the key steps in the process that could be expected, a brief description of the critical state and federal decision making processes, and a summary of the permits and approvals that may be required depending on how such a project is proposed to be constructed.

6.5.1 State Application and Decision Process

The WDNR and PSCW have developed a guidance document known as the Application Filing Requirement[136] to assist applicants and state agencies in reviewing wind projects that require either a construction approval under Wis. Stat. § 196.49 or certificate of public convenience and necessity under Wis. Stat. § 196.491 from the PSCW. Although this document was intended to provide guidance for the construction of terrestrial wind projects, it provides a good overview of the steps that could be expected for an off-shore wind project. One key difference between a terrestrial wind project and an off-shore project would be the need to obtain approval from the WDNR or the Legislature to place structures on the bed of the Great Lakes.

In general, when applications are submitted to the PSCW for utility facilities as defined in Wis. Stat § 30.025, the permit procedures under that section may be utilized for the processing of the permits. Both Wis. Stats. §§ 30.025 and 196.491(3)(a)3 set forth the framework and process for cooperation between the PSCW and WDNR so that each agency may meet its statutory obligations with respect to construction of an electric generating facility of 100 MW or larger. An applicant seeking a certificate of public convenience and necessity under § 196.491 must first submit engineering plans to the WDNR not less than 60 days prior to seeking PSCW approval. This provides WDNR the opportunity to inspect the plans and determine what specific WDNR approvals will be necessary for construction of the electric generating facility. The WDNR is required to inform the applicant of the required approvals within 30 days and after receiving that information, the applicant must apply for all other permit approvals within 20 days.

[136] The application filing requirement document is available at http://psc.wi.gov/utilityinfo/electric/construction/powerPlantRequirements.htm.

Once the WDNR pre-application requirements have been met, the applicant may file an application for a certificate of public convenience and necessity with the PSCW. If the PSCW determines that the application is complete, a public hearing is scheduled, as required by § 196.491(3)(b), and the PSCW determines whether the application meets the criteria of § 196.491(3)(d). The PSCW's final determination must be made within 180 days of the date the PSCW received a complete application from the applicant under § 196.491(3)(g). Wis. Stat. § 30.025 requires that WDNR wetland and waterway permit decisions be made within 30 days of any PSCW order.

Due to the novelty of wind projects in the Great Lakes, it is likely that the PSCW would seek to develop a full environmental impact statement, rather than an environmental assessment, before approving a certificate of public convenience and necessity for any off-shore wind project. However, the WDNR and the PSCW could develop a generic joint EIS in advance of a project proposal under Wis. Admin. Code § PSC 4.40. A generic EIS could streamline the approval process by evaluating the potential effects of such projects in advance. Applicants would still be required to submit site-specific information when an actual project is proposed.

6.5.2 Federal Evaluation and Decision Process

The USACE evaluation of a Section 10 or a Section 404 permit application is a multifaceted process involving: (1) an evaluation of the proposal's impacts in accordance with the National Environmental Policy Act; (2) a determination of whether the proposal is contrary to the public interest; and (3) for Section 404 permits, a determination of whether the proposal complies with the Section 404(b)(1) Guidelines promulgated under 40 C.F.R. Part 230.

The USACE strongly encourages that applicants for any off-shore wind projects in Lakes Michigan or Superior seek a pre-application consultation. The pre-application consultation process allows the USACE and other federal, state, and local agencies to advise potential applicants of the studies or other information likely to be required during the federal evaluation of the project. The process also allows for advanced identification of site-specific issues and early assessment of viable alternatives.

In general, the public notice is the primary method used to advise interested parties of the proposed activity and for soliciting comments and gathering information necessary to evaluate the probable impacts on the public interest. However, in the case of a large and complicated project such as an off-shore wind project, the USACE would likely use the environmental impact statement process under NEPA as the primary mechanism to solicit public involvement related to the project.

The decision of whether to issue a permit under both Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act will be based on an evaluation of the probable impacts, including cumulative impacts, of the proposed activity on the public interest. That decision will reflect the national concern for both protection and utilization of important resources. The benefit which reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the proposal will be considered, including the cumulative effects. Among those are conservation, economics, aesthetics, general environmental concerns, wetlands, cultural values, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shoreline erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production and, and in general, the needs and welfare of the people.

The following criteria would be considered during the evaluation of a permit application: (1) the relative extent of the public and private need for the proposed structure or work; (2) where there are unresolved conflicts as to the resource use, the practicability of using reasonable alternative locations and methods to accomplish the objective of the proposed structure or work; and (3) the extent and permanence of the beneficial and detrimental effects that the proposed project is likely to have on the public and private uses to which an area is suited.

The USACE reviews permit applications for the discharge dredge or fill material in waters of the United Stated under Section 404 of the Clean Water Act in accordance with guidelines promulgated by the U.S. EPA pursuant to Section 404(b)(1) of the Clean Water Act. Section 404(b)(1) guidelines require that no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences.[137] The policies and procedures for implementing the section 404(b)(1) guidelines were set forth in a Mitigation Memorandum of Agreement (MOA) issued by the U.S. EPA and the USACE on February 7, 1990. According to the MOA, "The Corps will strive to avoid adverse impacts and offset unavoidable adverse impacts to existing aquatic resources, and for wetlands, will strive to achieve a goal of no overall net loss of values and functions." To carry out this policy, the USACE will, in general, evaluate Section 404 applications by gathering and reviewing all information on a project, including potential mitigation, at the same time. Then the USACE first makes a determination whether potential impacts have been avoided to the maximum extent practicable. The USACE will next mitigate unavoidable impacts, to the extent appropriate and practicable, by requiring steps to minimize those impacts. Finally, the USACE will mitigate unavoidable impacts, to the extent appropriate and practicable, by requiring steps to compensate for aquatic resource functions and values. In some cases, it may be appropriate to deviate from the above sequence when the discharge is necessary to avoid environmental harm or when the proposed discharge can reasonably be expected to result in environmental gain or insignificant environmental losses.

In determining "appropriate and practicable" measures to offset unavoidable impacts, consideration is given to the scope and degree of those impacts and practicability in terms of cost, existing technology, and logistics in light of overall project purpose. The USACE will give full consideration to the views of other resource agencies when making this determination. A permit will be denied if the discharge that would be authorized would not comply with the section 404(b)(1) guidelines. If the proposed discharge complies with the section 404(b)(1) guidelines, a permit will generally be issued unless it is determined to be contrary to the public interest or the project fails to receive state water quality certification under section 401 of the Clean Water Act.

[137] The cornerstone of both NEPA and the section 404(b)(1) guidelines is a thorough identification and evaluation of alternatives, including the no action alternative.

6.5.3 Summary of Major Permits and Regulatory Approvals Required

The following tables summarize the major regulatory and permitting requirements that would be applicable to wind projects located in the Great lakes. Table 1 demonstrates permitting requirements for a facility with a generating capacity larger than 100 MW, while Table 2 demonstrates permitting requirements for a smaller project. In both cases, it is assumed that underwater transmission facilities longer than one mile and operating at greater than 100 kV would be required. It should be noted that these tables do not include every regulatory requirement; other permits and approvals may be necessary for a specific project, as discussed elsewhere in this Chapter.

Table 6.1: Generation Facilities 100 MW or Larger[138]

Regulatory Requirement		**Project Proponent**		
Permit or Approval	**Primary Agency**	**Non-Utility Local Government**	**Private Non-Utility**	**Public Utility**
Approval of electric generation facilities	PSCW	Wis. Stat. § 196.491	Wis. Stat. § 196.491	Wis. Stat. § 196.491
Approval for placement of lakebed structures (non-transmission)	WDNR	Wis. Stats. §§ 30.025 and 30.12, 13.097, or 24.39	Wis. Stats. §§ 30.025 and 30.12	Wis. Stats. §§ 30.025 and 30.21 or 30.12
Approval for placement of underwater transmission lines	WDNR and PSCW	NA	NA	Wis. Stats. §§ 30.025, 182.017 and 196.491
Clean Water Act Section 404 permit	USACE	Yes	Yes	Yes
Rivers and Harbors Act Section 10 permit	USACE	Yes	Yes	Yes
WEPA review	PSCW	Wis. Admin. Code § PSC 4.30 (EIS)	Wis. Admin. Code § PSC 4.30 (EIS)	Wis. Admin. Code § PSC 4.30 (EIS)
NEPA review	USACE	EIS or EA	EIS or EA	EIS or EA
CZMA consistency	WCMP	Yes	Yes	Yes

[138] Tables 6.1 and 6.2 summarize the major permits or approvals that would be necessary for an off-shore wind project and are not intended to be a comprehensive list of regulatory requirements.

Table 6.2: Generation Facilities Smaller Than 100 MW

Regulatory Requirement		Project Proponent		
Permit or Approval	**Primary Agency**	**Non-Utility Local Government**	**Private Non-Utility**	**Public Utility**
Approval of electric generation facilities	PSCW	None	None	Wis. Stat. § 196.49
Approval for placement of lakebed structures (non-transmission)	WDNR	Wis. Stats. §§ 30.12, 13.097, or 24.39	Wis. Stat. § 30.12	Wis. Stats. §§ 30.025 and 30.21 or 30.12
Approval for placement of underwater transmission lines	WDNR and PSCW	NA	NA	Wis. Stats. §§ 30.025, 182.017 and 196.491
Clean Water Act Section 404 permit	USACE	Yes	Yes	Yes
Rivers and Harbors Act Section 10 permit	USACE	Yes	Yes	Yes
WEPA review	WDNR or PSCW	Wis. Admin. Code § NR 150 (EA or EIS)	Wis. Admin. Code § NR 150 (EA or EIS)	Wis. Admin. Code § PSC 4.30 (EIS) or § PSC 4.20 (EA)
NEPA review	USACE	EIS or EA	EIS or EA	EIS or EA
CZMA consistency	WCMP	Yes	Yes	Yes

7. COMMUNITY INVOLVEMENT OF OFF-SHORE WIND / PUBLIC COMMENT

Regardless of where wind projects are located, the proposed projects are likely to uncover questions, interest, curiosity, and perhaps even concern from those that live and work near them. Addressing community questions and concerns, educating the surrounding public and listening to stakeholder input are important elements in gaining public acceptance and / or support for a wind project. To this end, the Community Involvement Work Group began gathering information about how Wisconsin citizens view wind energy, and specifically, off-shore wind projects in the Great Lakes.

The charge of the Community Involvement Work Group was to provide Wisconsin Great Lakes communities with information and solicit feedback on the investigation of off-shore wind in Lakes Michigan and Superior. For the purpose of this report, the Work Group interpreted community in the broadest sense and attempted to reach out to a wide variety of stakeholders.

7.1 Outreach Effort

The Work Group utilized outreach materials, presentations, informal briefing opportunities, previously scheduled meetings and events, and member communications (newsletters and list servers) to introduce this off-shore wind investigation and highlight the charge of this Work Group. The goal of these contacts was to encourage feedback and engage stakeholders.

7.1.1 Outreach Communication and Constituent Groups Contacted

An outreach, summary document was written detailing this off-shore wind investigation, its purpose, the charge of the individual Work Groups and instructions on how to follow the initiative through registration on the PSCW's Electronic Regulatory Filing (ERF) system. The document also listed Department of Administration and Community Involvement Work Group contact information.

The summary document on Wisconsin's off-shore wind investigation was presented and distributed at meeting events through list servers and posted on the Wisconsin Coastal Management Program's web site. Additional materials were made available and distributed to the Wisconsin Commercial Ports and Wisconsin Harbor Towns Associations, the Lake Superior Bi-National Forum and the Wisconsin Coastal Management Council.

The Group also capitalized on presentation or informal briefing opportunities when available throughout the time this investigation was ongoing. A presentation was made at the Lake Michigan stakeholders meeting which includes representation from local governments, regional planning commissions, state and federal agencies, private property interests and nonprofit environmental organizations. Additional presentations on the initiative were given to the Wisconsin Coastal Management Council, three Wisconsin Counties Association (WCA) Steering Committees (Environment and Land Use, Agriculture, and Transportation and Public Works), and the WCA Board of Directors. A presentation was also given at the Clean Water Conference which was attended by many Wisconsin Great Lakes city mayors and public officials. Direct contacts were made to seek input from stakeholders in the tourism, commercial ports, sport fishing, academia and environmental groups. The Community Involvement Work Group members who attended these events and distributed materials rated the feedback as generally positive.

An article on this investigation was drafted for publication in the Wisconsin Towns Association's and the Wisconsin Counties Association's newsletters. A similar article was also distributed to the Wisconsin League of Municipalities and Alliance of Cities.

7.1.2 Public Input

Despite the group circulating the summary document, including an article on Wisconsin's investigation of off-shore wind in several newsletters and other communications and highlighting the investigation at in-person opportunities, feedback was not abundant. While verbal feedback at above-described presentations and other in-person outreach opportunities was generally positive, the group did not receive any public comment into the designated e-mail account listed in member newsletters and other communications. In an attempt to further stimulate preliminary community opinion about an off-shore wind development in Lake Superior or Lake Michigan, the Work Group organized informal focus group research in Manitowoc and Racine to seek comments on the potential for Great Lakes wind generation.

Two focus groups were held - one in Manitowoc on August 5, 2008, and one in Racine on August 6, 2008. Twelve people participated in the Manitowoc session and eleven people attended the session in Racine. Manitowoc and Racine were chosen as communities for focus group research because they are two Wisconsin locations along the shores of Lake Michigan where wind resources have been shown to be strong near the Great Lakes. It should not be assumed that this informal research signals the onset of an off-shore wind project off the shores of either or both of these cities. Additionally, the focus group research conducted for the purpose of this investigation was done with the sole objective of viewing a small slice of Wisconsin community members' ideas and concerns about off-shore wind in the absence of other public input described earlier in this chapter.

7.1.2.1 Public Input from Focus Group Research

Although the focus groups cannot be considered representative of the general Wisconsin population and thus results should not be generalized, there were a number of key findings from the Manitowoc and Racine focus groups.

- Participants neither rejected the idea of wind turbines outright, nor did they unreservedly embrace it. They advocated weighing what would be gained with off-shore wind versus what energy options Wisconsin currently has in its portfolio.

- Participants did not see wind energy as the silver bullet. They stressed the importance of considering wind with all of the other power sources available. They believed that it will take a balanced approach to solve problems connected to climate change and energy independence. They expressed a strong desire for a long-term, comprehensive strategy.

- There was some concern about how Wisconsin would know whether large wind energy projects were the right direction to take. For example, participants wanted to know the effectiveness of wind power compared to other power sources.

- At the same time, participants felt that they were ready to try a new energy source - especially if it would be cost effective. Many participants agreed the market should determine the directions taken.

- Participants felt that Wisconsin should be a leader in the emerging wind energy industry.

- Participants felt that current information was paramount if good decisions were to be made. Both groups felt that education was the key to good decision-making regarding wind turbines and energy production in general. They want to be better informed before making any decisions about off-shore wind.

7.1.2.2 Public Input from Other Sources

Members of the public could enter public comment on the PSCW's ERF under docket 5-EI-144 or offer public comment at any of the Work Group meetings. EWindfarms, Inc. posted a comment to this docket indicating its support for an off-shore wind demonstration project in Lake Michigan. No other written comments were received via ERF en route to this group's draft report.

7.2 Lessons Learned from Previous Efforts/Proposed Projects

7.2.1 Public Opinion / Lessons Learned from Previous International Efforts

The experience of European wind project projects in operation since the 1990s provides insight into public opinion concerning off-shore wind. Regarding wind power in general, the European Wind Energy Association (EWEA) reports that public opinion surveys have shown that a very large majority of European citizens are in favor of wind energy.[139] The 2007 Eurobarometer questionnaire states that 71 percent of EU citizens are very positive about the use of wind energy in their country.[140] However, few opinion surveys concerning off-shore wind energy seem to be available.

One detailed public opinion study, a report entitled *Danish Off-shore Wind: Key Environmental Issues*[141] reveals that in Denmark, both local and national populations feel positively about off-shore wind projects. However, there is a difference in attitudes between the two local Danish areas of Horns Rev and Nysted, and also between the attitudes at the local and

[139] http://www.ewea.org/index.php?id=202
[140] Energy Technologies: Knowledge, Perception, Measures. European Commission, 2006.
[141] Danish Off-shore Wind: Key Environmental Issues. DONG Energy, Vattenfall, The Danish Energy Authority and The Danish Forest and Nature Agency, November 2006. Available http://www.ens.dk/graphics/Publikationer/Havvindmoeller/havvindmoellebog_nov_2006_skrm.pdf

national level. Most opposition to off-shore wind projects in Denmark appears to be related to local visual impact, although there have been concerns about possible environmental impacts. It is worth noting that Horns Rev is located 14 kilometers[142] - or just over 8.6 miles - from the Danish shore. Some of the turbines that are part of the Nysted project are ten kilometers[143] - or a little over six miles from shore.

Results of the *Danish Off-shore Wind* study show a number of underlying reasons for respondents' positive or negative attitudes. Positive attitudes were motivated by environmental concerns, reliability of supply, exports, and employment benefits. Those with environmental concern were split in two groups; one who put emphasis on CO_2 emissions and one who emphasized pollution by NOX and SO_2 as their main concern.

Among the Danish respondents who expressed a negative attitude, two issues were in focus. First, visual intrusions were a concern. Second, there was a concern that the wind projects would have a negative impact on the environment. The loss of the undisturbed view of the coastline and the ocean was mentioned by several respondents as a major issue. Another source of concern and negative attitude was the light markers for air traffic, which were seen as a major aesthetic and landscape disturbing factor.

The respondents were asked to what extent they perceived wind projects as a danger to birds and marine animals. Between 22 percent and 29 percent of the respondents in three samples stated that they believed the wind project to have a negative or very negative effect on bird life. In comparison, only 12 percent to 19 percent answered that wind projects would have a negative or very negative effect on underwater marine wildlife.

A notable finding of the *Danish Off-shore Wind* study also shows that the opposition against the wind project at Horns Rev was greater before construction. This negative attitude gradually diminished, and the report states that by 2004, the general attitude could be described as neutral or even slightly positive towards the off-shore wind project. Interviews revealed that there were two major concerns which caused the initial opposition. First, the respondents pointed to the decision-making process which was seen as highly centralized and with no local "co-decision" when it came to placing the wind project. Second, there was a major concern that the wind project would cause extensive visual intrusions and thereby result in a radical reduction in the number of visiting tourists. The Danish report notes that as time has passed, the discontent with the decision process has worn off and the negative effect on tourism has not occurred thus resulting in reduced opposition.

As the *Danish Off-shore Wind* study concludes, the environmental impacts of wind power development can be reduced by selecting appropriate sites for development. From this particular study it can be concluded that it is important to be aware of local variations in public opinion.

[142] http://www.hornsrev.dk/index.en.html
[143] http://uk.nystedhavmoellepark.dk/

According to a 2002 report authored by Off-shore Wind Energy Europe (OWE)[144], there is no absolute clear conclusion as to the social acceptance of off-shore wind power compared to on-shore. Drawing upon experiences from the off-shore farms already established OWE offers the following conclusions:

- public acceptance in general is high but falls when it comes to a population's own living surroundings,
- coastal areas are more sensitive to change because of great recreational values,
- local acceptance seems to increase after the installation of turbines, provided that no disturbances are experienced,
- public acceptance increases with the level of information and economic involvement,
- the degree of involvement of the local population in the planning phase influences public acceptance,
- the procedures on public involvement (hearings, etc.) vary considerably among countries and may even vary among regions within the same country, with no clear overview on the results of different strategies for public involvement and conflict management.

OWE suggests that the question of social acceptance really has many components, including the general attitude toward off-shore wind power in the population as a whole, the acceptance in the population who will experience the local impacts, the conflict management strategies utilized, and the economic involvement of populations affected.

7.2.2 Public Opinion Lessons Learned from Previous Domestic Efforts

As perhaps the most well-known off-shore wind project in the United States, Cape Wind, the Nantucket Sound wind project, has generated much public opinion controversy. The project has experienced both opposition and support. According to Cape Wind Associates[145], over 5,000 parties sent in written comments and hundreds spoke at the four public hearings on the proposed project's Draft Environmental Impact Statement, during a 108-day comment period.

As the European experience demonstrates and the *Danish Off-shore Wind* study notes, in many countries there is frequent local opposition to planning applications for wind projects despite the general view among objectors that wind projects should be developed (somewhere else) as a means of reducing CO2 emissions. Social acceptance of wind power has often been characterized by such a "not in my backyard" syndrome. This might be said to be the case with the Cape Wind project. Cape Wind's principal opponent, the Alliance to Protect Nantucket Sound[146], opposes the Cape Wind project for the following reasons:

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[144] Concerted Action on Off-shore Wind Energy in Europe, Off-shore Wind Energy Europe, 2002. Available: http://www.off-shorewindenergy.org/ca-owee/indexpages/Social_and_Environmental.php?file=envimpct_p4.php

[145] http://www.capewind.org/article88.htm

[146] http://www.saveoursound.org/site/PageServer?pagename=About_Us_Mission_Our_Position

- Public trust violation: The Alliance is concerned that the proposed plant represents seizure of 25 square miles of public trust lands in Nantucket Sound without competitive bidding.

- Economic effects: The Alliance claims the project is a net cost to the public and would receive well over $1 billion in subsidies and tax credits. There is concern for economic losses for fishermen, tourism and other businesses, and a loss of property values and the tax base for the region.

- Environmental hazard: Nantucket Sound is a well-recognized rich ecological resource that qualifies for and deserves federal protected status. There is concern that a power plant in this ecosystem could degrade or destroy vital habitat for birds, fish and other marine life, and pose a serious threat to the near-shore fishing industry.

- Aesthetic pollution: The proposed wind energy plant is an expansive industrial complex of 130 wind turbines, each 440 feet tall covering a 25 square mile area the size of Manhattan. Flashing red and amber lights, as well as fog horns, would cause visual, noise, and light pollution.

- Safety hazard: There is concern that the project will pose a clear danger to air and sea navigation, and to the thousands of recreational boaters and commercial fishermen who use Nantucket Sound for their livelihood and leisure.

- Electricity pricing: Because of the high cost of constructing off-shore wind projects, there is concern that wind-generated electricity might be expensive to produce.

According to a University of Delaware study[147], while the Cape Wind debate in Massachusetts appears to indicate that public opinion might be an impediment to off-shore wind development, the Delaware public has overwhelmingly supported a proposed project by Bluewater Wind. Opposition to the Delaware project has come from the electric industry and some members of the Delaware State legislature. The Delaware PSC has received well over 2000 public comments on this bid, more than any previous docket in the history of the Delaware PSC. Concerns of the Delaware public include:

- Climate change: Delawareans are more concerned about the future of the world in a general sense, and seem to see an off-shore wind project as a leading step toward prevention and mitigation.

- Personal/community health: Whether it is true or not, residents believe that the local coal-fired power plant is causing apparently elevated numbers of cases of cancer, developmental problems, and various respiratory ailments.

[147] Delaware Public Opinion: An Indicator of East Coast Off-shore Wind Development Potential. Jacqueline Piero, University of Delaware, June 2008. Presentation at the AWEA Windpower 2008 Conference and Exhibition.

- Jobs: Initial (and short-lived) Union concerns that an off-shore wind project would not provide jobs have given way to worry that jobs will be exported to neighboring states if land-based wind is purchased from Pennsylvania, Virginia, and Maryland.

- Aesthetic concerns: Generally thought to be a major drawback of wind power, and often cited on Cape Cod, have not been a major consideration here.

- Pricing: Surveys have shown residents are often willing to pay more for off-shore wind power than they pay now.

The Delaware study concludes that public opposition may not be a given in all locations, and changing social climate may only increase positive public attitudes toward off-shore wind.

Thus far, each proposed project, be it in Europe or the United States, has begun with distinct development plans and faced unique challenges. Public opinion on the topic of off-shore wind often involves a sizable amount of comments from interested parties. Overall, it is clear that the issue of public acceptance deserves to be studied in more detail. This would need to occur both before and after the installation of an off-shore wind project, with public opinion likely to be subject to variation depending on the site of the proposed project.

7.3 Sample Community Involvement Plan

As mentioned in the previous section, wind projects such as those in Denmark or even off the shores of the United States have had development plans. Community stakeholders have had various degrees of involvement and impact on off-shore wind projects, but it is clear that early, transparent stakeholder involvement from communities nearby wind projects is essential to increase both community satisfaction with the project and the chance of project success overall.

Below is a sample Community Involvement Plan for off-shore wind projects, drafted with the objective of involving potentially affected stakeholders in the development of potential wind projects to solicit input and support. A wind energy developer intending to embark upon an off-shore project should draft and use an original plan that includes some or all of these elements very early in the process. Similarly, the developer should allocate a budget for community outreach and reach out to key static members of the community to bring them into the process early and help educate the public and answer stakeholder questions.

Table 7.1: Community Involvement Plan

Activity	Objective	Timeframe
Identify potential stakeholders in the project, including but not limited to: • State regulatory agencies • Elected officials • Indian tribes and tribal government • Environmental groups • Recreational user groups • Utility industry colleagues • Trade groups • Labor groups • Faith organizations • Business community • Nearby local governments • Federal regulatory agencies • Opposition groups • Wind energy advocates • Media • …and many more	Identify as many potential stakeholders as possible to develop the intended participation group as part of a public involvement plan. Identify issues. Actively seek out potential opposition and bring them to the table early.	Two to three years before a site is chosen.
Develop a Public Involvement Plan	Form a plan for stakeholder engagement. Identify strategies to allow for different levels of engagement.	Two to three years before a site is chosen.
Work with regulators and elected officials to understand the options	Identify parameters of what is feasible and where there are red flags	Two to three years before a site is chosen.

Community Involvement Plan (cont.)

Activity	Objective	Timeframe
Solicit public involvement around the need for the project and the process first	Begin a dialogue about the project, what need it serves, what the benefits are and solicit input as to the potential for siting. Share the process that will be used to make siting decisions, show where public involvement fits and explain the regulatory process. Ask stakeholders to provide specific input on opportunities as well as challenges. Possible tools for soliciting input: Open houses Taskforces Workshops Mailing Surveys News stories And others……	Two years before a site is chosen.
Using the public input received, make choices as to potential sites and go through another round of sharing information and receiving input Depending on the number of options available this cycle may be repeated multiple times	Vet ideas with stakeholders and get additional input. Make the process transparent. Where there are limited or no options, explain why. Continue to discuss the need and benefits of the project.	Over the course of one to two years before a site is chosen.

Community Involvement Plan (cont.)

Activity	Objective	Timeframe
Share project decisions and choices	Continue to be transparent. Set expectations for the regulatory process. Encourage involvement in the regulatory process	Prior to filing a project application
Continue to communicate through regulatory process	Stay in touch with stakeholders Encourage participation in the case	Through regulatory review
After decision, continue to communicate	Provide accurate and accessible information Set expectations of construction	After regulatory decision

8. NEXT STEPS

This report is a first step in the State's investigation of the potential for wind generation on the Great Lakes. Should the State decide to move forward with the next phase of the investigation, the Study Group has compiled a list of topics that warrant a more detailed investigation. The reader should keep in mind that the Study Group was not asked to draw conclusions about whether off-shore wind generation is in the best interests of the State of Wisconsin or its citizens. Hence, the following "next steps" are intended to inform the PSCW should it move forward with an off-shore initiative.

This report confirms that off-shore wind projects represent an alternative approach to meeting the State's energy needs, but pursuit of such projects will require the State to make definitive policy choices. During the course of its investigation, the Study Group identified numerous benefits as well as challenges to the development of off-shore wind power in the Great Lakes. To assist policy makers in evaluating various energy options, including off-shore wind power, the Study Group identified several options for addressing some of the most significant information gaps, technical constraints, or legal impediments to the development of off-shore wind.

8.1 Information Gaps

One of the biggest challenges to the development of off-shore wind projects in the Great Lakes is the lack of experience and information necessary to make informed decisions about the costs, construction, operation, and effects on the humans, wildlife and the general environment of such projects. The Engineering and Economics Work Group found that while some projects have been built, none are located in freshwater environments and none are currently operating in the United States. While some inferences and assumptions can be drawn from the experience of both off-shore and terrestrial wind projects elsewhere, the lack of specific information about off-shore wind projects in the Great Lakes leads to regulatory, environmental, and financial uncertainty for both policy makers and those wishing to develop such projects.

If the State decides to continue its investigation of the use of off-shore wind energy, this uncertainty could be minimized by collecting basic information that would lead to better-informed project applications to the Commission and other regulatory authorities. This information should be collected in advance of an actual project proposal and be made available to the public.

Specifically, the Study Group believes that it would be beneficial to collect comprehensive wind data for Lakes Michigan and Superior and to develop a wind potentials map that could be used in evaluating various project locations. This would help not only in identifying the best wind resources, but it would be useful in planning for the development of other infrastructure, such as transmission facilities, that could support both on-land and off-shore wind development. At a minimum, the Study Group believes that three years of data would develop a robust, complete profile of wind resources on the Great Lakes, although it is possible that point-specific resource certainty may be measured in a shorter window of time.

Once the best wind resources have been identified, the wind potentials map could be used to identify locations where wind projects should be avoided due to conflicts with recreational or commercial uses, the presence of legally protected areas, or other natural resources concerns such as fisheries, birds, or bats. An additional advantage is that once the most appropriate locations for off-shore wind power have been identified based on their geographic, meteorological, and legal characteristics, policy makers will be able to direct limited funding resources towards targeted study areas where wind projects are likely to be located. This will allow for more in-depth study of the possible effects of wind projects in specific, high potential areas.

Obviously, collecting this data is a large undertaking that will require a significant investment of resources. While some of this data could be collected through the development of a generic environmental impact statement, the State may wish to pursue partnerships with other Great Lakes states, federal agencies such as the National Oceanic and Atmospheric Administration, the wind power industry, and other interest groups to improve data sharing and collaboration.

8.2 Technical Constraints

While the Study Group believes that it is feasible to develop off-shore wind generation facilities on the Great Lakes using existing technology, a number of technical constraints exist. As noted, no off-shore wind project has been built in the United States. Furthermore, no project has been built in freshwater anywhere in the world. As a result, an off-shore wind project in the Great Lakes may require innovative engineering or technological solutions compared to projects that are located on land or in salt-water environments.

First, innovative designs for the turbines or their foundations may be needed, depending on where a project will be located. For example, off-shore wind projects have been installed at depths of up to 30 meters, but designs for deeper water foundations are still under development. If it is determined that wind resources in the shallower portions of the Great Lakes are inadequate, it may be necessary to design foundations that are capable of being used at depths greater than 30 meters.

Second, specialized vessels capable of placing large structures in deep water may be required for the construction of an off-shore wind project. The Study Group found that there are no vessels currently operating in the Great Lakes that would be capable of constructing some of the turbine foundation designs that were evaluated. In addition, there are questions about whether existing navigation channels are sufficient to allow these specialized vessels to enter the Great Lakes. Moreover, the costs of bringing a vessel into the Great Lakes may be prohibitive because there is a high demand for these vessels worldwide and because federal law requires that ships carrying merchandise or passengers in U.S. territorial waters or between U.S. ports be U.S.-built, owned, and documented by the United States Coast Guard. As a result, it may be necessary to determine whether the necessary assets can be acquired before a project could feasibly proceed.

Third, the Engineering and Economics Work Group found that while the Great Lakes present unique design challenges due to the presence of ice in the winter, existing technology would be sufficient to address the ice conditions expected on the Great Lakes. This Work Group identified a number of cold weather turbine adaptations that may be needed in the Great Lakes including: special coatings to prevent ice buildup on foundations, towers, blades, and nacelles; modified foundations with ice-breaking collars; and specialized vessels such as ice sleds for winter maintenance or ice breaking vessels for extreme ice conditions. However, additional information is needed to optimize the available designs to withstand the expected icing environments. Such information may be available from the USACE, which has experience in designing, constructing, and maintaining structures in the Great Lakes.

Finally, the Study Group identified concerns about the ability of existing transmission infrastructure to support the development of off-shore wind projects. While smaller projects near load centers could be supported by the existing transmission system, larger projects would likely require upgrades or additions. As a result, if the State decides to pursue off-shore wind, the Study Group recommends that it complete a transmission development study near the Lake Michigan shore in Eastern Wisconsin. This study could consider both in-lake and on-land transmission facilities to support the development of terrestrial and off-shore wind resources. This area of the state is one of the most studied areas for the development of wind projects and has a number of pending interconnection requests for wind projects. Development of this transmission corridor would place additional transmission near major load centers and could provide reliability and economic benefits to Wisconsin in addition to supporting wind energy development.

8.3 Legal Issues

The Legal Work Group identified a number of legal issues connected to wind generation projects on the Great Lakes. Most significantly, it is unclear whether the placement of the necessary infrastructure on the beds of the Great Lakes is permittable under existing Wisconsin law. While WDNR believes it can authorize public utilities, municipalities, and riparian landowners to place some structures on the beds of navigable waters under existing statutes, it is not clear that the placement of wind turbines in navigable waters far from shore could be authorized under existing statutory processes. The Work Group believes that it would be beneficial for the Wisconsin Legislature to address the legal questions about the placement of wind turbines in the Great Lakes by clarifying which entities may apply for permits and by establishing standards for siting and permitting off-shore wind projects.

Wisconsin currently has provisions to authorize the leasing of the beds of navigable waters by the Board of Commissioners of Public Lands for limited purposes and where it is determined that such uses are consistent with the public interest in navigable waters. The current laws in Wisconsin do not authorize such leases for uses such as wind turbines. The Work Group believes it would be prudent to have the Wisconsin Legislature address these questions.

In addition, the Work Group found that not all off-shore wind projects in the Great Lakes would be subject to oversight and approval by the PSCW under existing law. As a matter of policy, the Work Group believes that it may be beneficial to ensure that any off-shore wind project require a certificate of public convenience and necessity from the PSCW. As part of its approval process, the PSCW must find that the costs are reasonable in relation to the benefits of such a project. Although the costs of developing such a project are difficult to estimate, it is likely the cost of an off-shore wind project may exceed other alternative sources of energy, including terrestrial wind projects. However, by requiring a certificate of public convenience and necessity regardless of the size of an off-shore wind project, the State could ensure that the PSCW balances these costs with other policy goals, including the State's renewable portfolio standard.

Finally, due to the number of overlapping federal jurisdictions and federal laws that would be involved with a review of off-shore wind projects in the Great Lakes, the Work Group believes that it may be beneficial for a single federal agency to serve as the lead agency for coordinating the federal review of such projects. Because the Army Corps of Engineers has significant jurisdiction and experience with other large-scale projects in the Great Lakes, it may be appropriate to designate this agency to serve in this role. Under Section 388 of the Energy Policy Act of 2005 (Public Law 109-58), the U.S. Minerals Management Service serves a similar role in reviewing wind energy projects on the Outer Continental Shelf.

8.4 Additional Steps for Potential Developers of Off-Shore Wind Projects

The above observations identify suggested information gaps, technical constraints and legal changes that would likely need to be addressed for successful off-shore wind projects in the Great Lakes. While not intended to be comprehensive, the following list provides additional steps that project developers should consider in connection with a potential off-shore wind project in the Great Lakes.

- Any developer considering an actual project on the Great Lakes should plan for early consultation with federal, state, local and tribal governments before concentrating on any one project site. The best way to avoid some of the potential adverse environmental and cultural resource impacts of an off-shore wind project is through careful site selection. Early consultation with all levels of government may help raise awareness about potential legal or permitting impediments, transmission needs, and other factors.

- Developers should engage the communities near a potential off-shore wind project early and often.

- Any developer considering an actual project on the Great Lakes should anticipate the need for detailed site-specific assessments of natural resources and potential impacts, understanding that they themselves may be called upon to answer some of the scientific unknowns.

- Prior to early agency coordination meetings, prospective developers should develop specific plans for the evaluation of bird and bat usage of the airspace in and around the proposed site area that include use of horizontal and vertical radar if data does not exist.

- The potential human impacts of an off-shore project are similar - and may be lesser - compared to the impacts of terrestrial wind projects and other energy infrastructure projects. Site-specific conditions will always be an important factor. Based on available information about off-shore projects, we expect that visual/aesthetic impacts are different than on land, but will still be an issue of public concern.

- Site selection should consider potential for impacts to commercial and recreational fishing operations, shipping lanes, military use areas, and marine communications.

- Careful design of a project could incorporate protections and enhancements for aquatic resources.

APPENDIX A – WISCONSIN OFF-SHORE WIND STUDY GROUP MEMBERS AND WORK GROUP MEMBERS

Off-Shore Wind Main Study Group Members

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APPENDIX B – GLOSSARY

Aids to Navigation	Devices external to a vessel or aircraft specifically intended to assist navigators in determining their position or safe course, or to warn them of dangers or obstructions to navigation.
Aquatic invasive species	Aquatic and terrestrial organisms and plants that have been introduced into new ecosystems (e.g. the Great Lakes) and are both harming the natural resources in these ecosystems and threatening the human use of these resources.
Capacity factor	Comparison of a tower or wind energy project's actual power production over a given time with the amount of power that it would have produced if the tower or wind energy project had run at full capacity for the same amount of time.
Design life	The period of time an item is expected to work within its specified parameters or the life expectancy of an item.
Directional drilling	A method of installing underground conduits and cables in a shallow arc along a prescribed bore path by using a surface launched drilling rig, with minimal impact on the surrounding area.
Downriggers	Devices used while trolling for fish which place lures at a desired depth.
Downwind turbine	A turbine design in which the blades are on the downwind side of the tower.
Drilling mud	A fluid used to drill holes in the earth.
Fall-out locations	Areas where flocks of birds land in unusually large numbers after flying for a long period of time over open water during migration or a storm.
Forage fish	Small fish which breed prolifically and serve as food for predatory fish.
Frac-out	A condition where drilling mud is released through fractured bedrock into the surrounding rock and travels toward the surface of a water body.
Fugitive emissions	In air pollution rules, an emission from a source other than a flue or stack.

Generator interconnection study	A study of the impacts to the existing system performed when a generator proposes to connect to the transmission system.
Geotechnical conditions	State of earth materials (i.e. soil, rock, cobble, etc.) in a specific location evaluated prior to design of structural elements such as foundations.
Ghosting	A double image when receiving a distorted signal from an analog television broadcast.
Important bird areas	Sites that support endangered or threatened species, species of greatest conservation need, significant concentrations of birds, and assemblages of birds associated with rare or representative habitat types.
Intake crib	An off-shore structure that collects water from close to the bottom of a lake to supply a pumping station on-shore.
Ice cone	Conically shaped element placed at water level to deflect ice from directly intersecting with a fixed structural object.
kV	kilovolts, or thousands of volts.
LIDAR	An acronym for Light Detection And Ranging. It is an optical remote sensing technology that measures the properties of scattered light. It allows you to measure distance, speed, rotation and chemical composition and concentration of a remote target such as a smoke plume or clouds. It is used to make topographical measurements and has also been used extensively in meteorological and atmospheric research.
Load	All the devices that consume electricity and make up the total demand for power at any given moment.
Mid-lake lake trout refuge	A deep-water area in central part of Lake Michigan that is off limits for commercial fishing. Lake trout may not be possessed by anglers within its boundaries.

Meter	3.28 feet; 10 meters – 32.8 feet.
MISO	Midwest Independent Transmission System Operator, running an energy market and managing the transmission grid that covers a 14 state area and part of a Canadian province.
Moment (overturning)	Force exerted on an object can create rotation of object about a point (ex. – high winds against a tree can lead to the tree tipping over).
MW	Megawatts, or millions of watts, commonly used to describe the capacity of generating units like wind turbines or other power plants.
Nacelle	An enclosure sitting at the top of the turbine tower that houses the drive train and gearbox, if there is one, the generator and other electrical or monitoring equipment and controls.
Pixelation	An effect caused by displaying an electronic image at such a large size that individual pixels are visible to the eye.
Post-contact	After first contact between European explorers and Native Americans.
Pound nets	Fish traps consisting of staked nets arranged so as to form an enclosure with a narrow opening.
Pre-contact	Prior to first contact between European explorers and Native Americans.
Renewable Portfolio Standard (RPS)	A state policy that requires electricity providers to obtain a minimum percentage of their power from renewable energy resources e.g., wind, bio-mass, hydro, by a certain date. Currently there are 24 states plus the District of Columbia that have RPS policies in place. Together these states account for more than half of the electricity sales in the United States.
Scour	Removal of lake bed sediment/rock around a fixed object due to the force of water (i.e. current, waves, etc.).

Sodar	Sonic detection and ranging (Sodar) systems are used to remotely measure the vertical turbulence structure and the wind profile of the lower layer of the atmosphere. Sodar systems are like **radar** (*radio detection and ranging*) systems except that sound waves rather than radio waves are used for detection. Other names used for sodar systems include **sounder**, **echosounder** and **acoustic radar.**
State special concern species	A WDNR designation of species about which some problem of abundance or distribution is suspected but not yet proved. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.
State species of greatest conservation need	Species identified by the State of Wisconsin as having low and/or declining populations that are in need of conservation action because they are: already listed as threatened or endangered; at risk because of threats to their life history needs or their habitats; stable in number in Wisconsin, but declining in adjacent states or nationally; or, of unknown status in Wisconsin and suspected to be vulnerable.
State-listed and federally-listed threatened and endangered species	"Endangered species" means any species whose continued existence as a viable component of Wisconsin's wild animals or wild plants is determined by WDNR to be in jeopardy on the basis of scientific evidence. "Threatened species" means any species of wild animals or wild plants which appears likely, within the foreseeable future, on the basis of scientific evidence to become endangered.

Substation	Place where transmission lines connect to each other and where protective equipment is located. Also where transformers are located to step the voltage up or down in order to put power into or take power out of the transmission network.
Traditional cultural properties	Sites important to a community's historically rooted beliefs, customs, and practices.
Transformer	Device that changes voltage levels.
Transition piece	Concrete, steel, or composite (steel/concrete) piece that attaches the wind turbine tower base (bottom) section to the wind turbine foundation.
Transmission system	An interconnected group of lines and equipment for transporting electric energy in bulk on a high voltage power line from a source or sources of power supply (e.g. power plant) to a point of use within a utility system or to a point of interconnection with another utility system or power grid.
Trap nets	Stationary nets that form a labyrinth-like chamber into which fish can easily enter, and from which they cannot easily escape.
Upwind turbine	A turbine design in which the blades are on the upwind side of the tower.
Yaw drives	A component of a wind turbine that keeps the rotor facing into the wind as the wind direction changes.

APPENDIX C - BENEFITS OF OFF-SHORE WIND GENERATION

The development of Wisconsin's off-shore wind resource could generate benefits for the state in terms of environmental quality, economic development and jobs, as well as, energy independence. It could also serve as a hedge against future fossil fuel price increases. All of these potential benefits are explained below.

C.1 The Positive Environmental Impacts of Wind Generation

A wind project on the Great Lakes would potentially have significant environmental impacts, both positive and negative. While the main report mostly details the potential negative environmental impacts, this section summarizes the positive environmental impacts of wind generation, specifically, reducing the air pollution, solid waste and water use that is normally associated with electricity generation. When evaluating an off-shore wind project, decision-makers should consider both the positive and negative environmental impacts.

To the extent that a Great Lakes wind project could provide electricity that would otherwise be generated by combustion of fossil fuels, adverse air quality impacts would be avoided. Combustion of natural gas produces substantial quantities of nitrogen oxides (NOx), carbon monoxide (CO), particulate matter (PM_{10}), and greenhouse gases (GHG), as well as smaller amounts of sulfur dioxide (SO_2), volatile organic compounds (VOC), and certain hazardous air pollutants (HAPs). Combustion of coal or oil produces substantial amounts of all of the above. Each of these pollutants is known to have potential human health, environmental, and/or global warming impacts.

The amounts and types of emissions avoided by a Great Lakes wind project would be virtually identical to the emissions avoided by a similarly-sized terrestrial wind project. In a recent Environmental Impact Statement (EIS) for a 200 MW terrestrial wind project, WDNR and PSCW compared the air pollutant emissions from recently approved natural gas and coal-fired power plants in Wisconsin. The results are summarized in the following table:

Table C-1: Contrast of Potential Annual Emissions in Tons Per Year for an Equivalent Amount of Energy Produced by the Weston Unit 4 Coal Plant, the Port Washington Combined-Cycle Natural Gas Plant, and the Forward Wind Project[148]

Pollutant	Weston 4	Port Washington	Forward
PM_{10}	529.2	98.3	0
CO	3,421	147.4	0
NOx	1,613	130.0	0
SO_2	2,266	3.74	0
VOC	85.0	13.8	0
Lead (Pb)	0.59	**	0
H_2SO_4	113.3	5.7	0
Mercury (Hg)	0.039	**	0
Beryllium (Be)	0.029	**	0
GHG	615,000	231,200	0

** Not a notable amount

Using similar reasoning, the "net" impact of any wind power project in terms of solid and hazardous wastes will also be positive. This holds true especially if energy from a coal-fired power plant is displaced, due to the large amounts of coal ash that must be managed.

Wind power is one of the few technologies that can be used for widespread generation of bulk power that does not also require the use of massive amounts of cooling water for the generation of electricity. If current concerns related to the water quality and water quantity impacts of conventional power plants continue to increase, this advantage of wind power may become increasingly important.

The "net positive" impacts of wind power described above are generic and apply to any wind power project regardless of location.

C.2 Wind Generation Will Enhance Economic Development and Create Wisconsin Jobs[149]

The economic development and job growth benefits of wind power are just being recognized in the United States. A number of companies in Wisconsin have grown their businesses rapidly and are adding jobs to address the growing demand for wind turbine components and related services. Wisconsin companies such as Michels Wind Energy, Wausaukee Composites, Tower Tech and others are realizing today the benefits of the rapidly-growing wind industry.

A recent report by the U.S. Department of Energy (DOE) considered one scenario where the United States would derive 20 percent of its electricity from wind power in 2030.[150] The

[148] Refer to page 54 of Final EIS at http://psc.wi.gov/apps/erf_share/view/viewdoc.aspx?docid=34146.
[149] This section describes some of the potential *direct* benefits of wind power generally and off-shore wind power specifically, in terms of economic development and job growth. It does not look at total *net* economic impacts.
[150] Refer to http://www.20percentwind.org/.

DOE report highlights the significant economic development and job growth opportunities associated with the wind industry. An analysis was performed to determine where industries exist today in the U.S. that make some of the 8,000 components and piece parts that are used to construct a typical wind turbine. Under the 20 percent scenario, Wisconsin was identified as one of the ten states that would benefit most in terms of job growth. Several others reports have also considered the job growth potential in the wind power industry, and Wisconsin is always listed as a top state due to its manufacturing infrastructure, skilled workforce, and academic support community.

The ability of terrestrial wind projects to create jobs is well documented, but less is known (especially in the U.S.) for off-shore wind. As detailed in Chapter Three of this report, off-shore projects require specialized vessels and other specialized equipment that currently may not be available in the United States or may be in high demand. If the off-shore wind industry takes off in the Great Lakes region and elsewhere, Wisconsin could potentially see new and increased manufacturing and export opportunities, not just in the wind-power components industry, but perhaps in the shipbuilding industry as well. But manufacturing jobs only tell part of the story.

The development of off-shore wind projects in the Great Lakes could also mean new jobs in construction and installation near project locations and, as has been seen in Europe, boosting of the economy in port cities and communities with marine industries. In conclusion, the deployment of off-shore wind energy might give a strong boost to job creation and regional development for Wisconsin communities near possible off-shore sites. The potential for creating well-paying jobs in sectors that support wind development, such as manufacturing, engineering, construction, transportation, and financial services could be very lucrative.

Finally, we note that in Europe off-shore wind turbines appear to be welcomed by tourists and may actually be boosting tourism. For example, wind parks off the shores of two major destinations in Denmark - the capital city of Copenhagen and the beach resort of Blavandshuk - are popular tourist attractions. Boat tours are available in Copenhagen for tourists interested in getting a closer look at the turbines. Increased tourism has also been noted at many terrestrial wind power project locations, perhaps most notably at a site near the casinos in Atlantic City, New Jersey. It is impossible to say whether off-shore turbines in the Great Lakes would increase tourism but the possibility cannot be dismissed.

C.3 Wind Generation Will Enhance Energy Independence and Provide a Hedge against Rising Fossil-Fuel Costs

An additional benefit of off-shore wind power in Wisconsin is the generation of electricity using a source of energy indigenous to Wisconsin. Wisconsin currently imports all of the natural gas, coal, and uranium used to generate electricity in the state. Furthermore, Wisconsin is a net importer of electricity. Consequently, the state exports billions of dollars each year to meet our energy needs.[151] Off-shore wind power could provide the means to keep a

[151] Wisconsin Energy Statistics 2007 (http://power.wisconsin.gov/docview.asp?docid=11632&locid=131) includes an estimate that $13 billion in energy expenditures left the state in 2006. An unspecified but large portion of this total was spent on coal, natural gas, and uranium for electric generation.

greater portion of our energy dollars in the state, rather than fueling the economies of other states and other nations.

Several studies have pointed to the possibility that rapid nationwide growth in wind power could ultimately reduce demand for natural gas as an electricity fuel, thus exerting both a downward pressure on natural gas prices and a downward pressure on natural gas price volatility.[152] For industries in Wisconsin that use natural gas in their processes, and for consumers who heat their homes in Wisconsin with natural gas, any such reduction in price or volatility would be a welcome benefit.

The price stability benefit of off-shore wind power is also significant and should not be underestimated. Once a wind project is built and all of the capital and construction costs are paid, the "fuel" is free. Operation and maintenance costs for off-shore wind projects are typically higher than for terrestrial wind projects, but these costs are fairly predictable and may be less than for some conventional power plants. Electricity from wind energy is thus less subject to the price volatility of other fuel sources used to generate electricity. Some electric utilities are now recognizing this fact and are viewing wind power as a "hedge" against fuel price volatility. And as the pressure for legislative action on global warming increases in the United States, it becomes more and more likely that fossil fuel plants will eventually have to pay a price for their greenhouse gas emissions. These additional costs could be quite high, thus increasing the hedge value to an electric utility from having a portfolio that includes a strong component of wind power.

[152] Refer for example to Ryan Wiser, Mark Bolinger, and Matthew St. Clair, "Putting downward pressure on natural gas prices: The impact of renewable energy and energy efficiency" (May 20, 2004). *Lawrence Berkeley National Laboratory*. Paper LBNL-54971. (http://repositories.cdlib.org/cgi/viewcontent.cgi?article=2413&context=lbnl)

APPENDIX D - ADDITIONAL INFORMATION FROM THE ENGINEERING AND ECONOMICS WORK GROUP

D.1 WIND

Estimated Off-shore Wind Production

Just as there is a range of wind speeds on-shore, there would also be a significant range of potential production at different off-shore project locations. Capacity factors could range from about 0.29 at the least windy sites to about 0.40 (after wind project losses) at the windiest site as set forth below in Table D.1-1. Each site would have a range of capacity factors, corresponding to a range of wind speeds.

As a general proposition, wind speeds would be higher above Lake Michigan than Green Bay or Lake Superior waters in Wisconsin. Wind speeds above Lake Michigan would increase rapidly in the first few miles off-shore, then more gradually as you continue further east. Off-shore wind speeds would be substantially higher than wind speeds at inland sites developed in Wisconsin to date. As a consequence of higher wind speeds, energy productivity (plant capacity factor) would be higher, sometimes much higher, at better off-shore sites than at the best current on-shore sites.

Table D-1: Production (Capacity Factor) at Hypothetical Wisconsin Off-Shore Project Sites

Lake Superior Site[153] (46˚45’ N, 90˚25’ W) – about 12 miles east-southeast of Big Bay Point on Madeline Island and about 12 miles north of Saxon Harbor:

< 100 MW[154]	Mean 7.5 to 8.0 m/s	> 100 MW[155]
.304 to .341		.297 to .333

Green Bay Site[156] (45˚ 02’N, 87˚ 30’ W) – about six miles southeast of Marinette and about nine miles north-northwest of Potawatami State Park:

< 100 MW[157]	Mean 7.4 to 7.8 m/s	> 100 MW[158]
.300 to .329		.296 to .325

153 This site was chosen for illustrative purposes only. It is not an endorsement of this site or its potential.
154 Assumed wind project losses at 14 percent.
155 Assumed wind project losses at 16 percent.
156 This site was chosen for illustrative purposes only. It is not an endorsement of this site or its potential.
157 Assumed wind project losses at 13 percent with 138-kV cross-Green Bay submarine cable through site.
158 Assumed wind project losses at 14 percent with 138-kV cross-Green Bay submarine cable through site.

Lake Michigan Sites – characterized by the distance east from the west shoreline of Lake Michigan:

< 100 MW[159]	Means 7.3 to 9.0 m/s	> 100 MW[160]
.293 to .343	2 miles out	.286 to .336
.321 to .376	5 miles out	.314 to .367
.348 to .402	20 miles out	.340 to .392

D.2 ICE

D.2.1 Ice Cover

Table D-2 below provides the percentages of February ice coverage based on 1973 to 2002 data from the Great Lakes Environmental Research Laboratory (GLERL) *Great Lakes Ice Atlas (Assel 2003)*. This table is based on *Ice Atlas'* weekly ice charts for February for median, third quartile, and maximum ice conditions during the 30-year period of record. It represents the ice climate of 1973 to 2002. It applies the charts to various locations in Lakes Michigan and Superior.

Table D-2: Percentage of February Ice Cover 1973-2002

	Lake Michigan 5 Miles Off-shore				Lake Superior	Lake Michigan 20 Miles Off-shore	
Ice Conditions	Kenosha-Racine Co. Line	Oak Creek	Edgewater	Manitowoc	46 degrees 45' N 90 degrees 30' W	Mid-Lake Plateau East of Fox Point	Two Rivers Ridge East of Cleveland
Median	45	45	5	5	90	5	5
Third	55	55	55	65	100	5	5
Maximum	100	100	100	100	100	95	95

While Table D-2 reflects the ice climate up through 2002, since that time, we have experienced increased mean winter temperatures and reduced icing on Lake Michigan.[161]

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[159] Assumed wind energy project losses at 13 percent when two and five miles out, and at 15 percent 20 miles out.
[160] Assumed wind energy project losses at 15 percent when two and five miles out, and at 17 percent 20 miles out.
[161] For the years 2002-2007 at Milwaukee, annual heating degree days ("HDD," January through December) were below the 1971-2000 normal of 7,087 every year and more than five percent below normal five out of six years. Mean annual temperatures were above the 1971-2000 normal five out of the six years. NOAA annual climate summaries for Milwaukee show:

Year	Actual Ann. HDD	Normal Ann. HDD	Mean Temp.	Normal Mean
2002	6551	7087	49.2 F	47.5 F
2003	7063	7087	46.9	47.5
2004	6663	7087	47.7	47.5

Warmer winter temperatures may result in harbors being open longer, thus decreasing operations & maintenance costs for off-shore wind turbines. Warmer winter temperatures may also lessen the need for highly robust ice protection for deep water installations; however, the ultimate ice protection design will be dictated by the authorities having permitting authority, the developer's engineer and the insurer of the development. Even with the possibility of warmer winters, near-shore wind installations will need to be designed to accommodate substantial icing, including moving ice floes of hard, cold, freshwater ice. In addition, maintaining wind turbines in a typical winter with some ice close to shore may require equipment such as ice boats, which can travel across ice and through water. In the event of an extreme ice situation, ice breakers and tugs might be necessary.

D.2.2 Ice Accumulations

Ice has typically accumulated in thickness to around 0.8 meters in sheltered bays on western Lake Superior such as Chequamegon Bay near Ashland. This is the historical level. However, in recent years, the average ice thickness has declined and is probably closer to 0.6 meters at Ashland.

Outside of Chequamegon Bay, at a potential deep-water site about five miles southeast of Madeline Island, average ice thickness is probably about half that in Ashland or about 0.3 meters. In 1979, this area experienced fast ice and the thickness probably reached about 0.6 meters. On the other hand, in some recent mild winters, this area has accumulated very little ice. Its current ice accumulation potential probably ranges from about .05 to 0.5 meters depending on winter severity.

Lake Michigan has lower ice accumulations. Green Bay typically has the thickest ice accumulation in the Wisconsin waters of Lake Michigan, with a current mean in an average winter of about 0.4 meters in the southern part of Green Bay. Ice thickness is typically closer to 0.35 meters further north in Green Bay. This past winter's (2007-08) ice thickness in Green Bay was above the recent average, reaching about 0.6 meters. The potential range in the bay currently is from about 0.2 meters in a mild winter to 0.7 meters in a severe winter.

Along the western shore of Lake Michigan, the thickest ice typically occurs in very shallow waters close to shore in northern Door County. This is typically about 0.25 meters, ranging from about .0 to about 0.5 meters, depending on winter severity. Lesser accumulations of ice occur in deeper water a few miles off-shore to the east, and little ice accumulates most years beyond five miles off-shore.

2005	6628	7087	49.2	47.5
2006	6043	7087	50.0	47.5
2007	6508	7087	48.9	47.5

See, e.g., www.crh.noaa.gov/images/mkx/climate/2007/mkeyr2007.pdf. for the 2007 summary. Some may view the 2002-2007 pattern as continued evidence of warming, especially in winter, when warming has the greatest implications relative to ice formation on the lake.

South of Door County on the western shore of Lake Michigan, ice accumulation is largely a function of water depth. At depths of less than 20 meters, ice accumulates typically to about 0.2 meters thick, ranging from about .0 to about 0.35 meters depending on winter severity. At depths of around 45 meters a few miles further out, ice accumulates typically to about 0.12 meters, ranging from about .0 to about 0.25 meters depending on winter severity.

On the Mid-Lake Plateau or Two Rivers Ridge more than 20 miles off-shore, ice accumulation is much less than in the shallows closer to shore. In a typical winter, there is no ice accumulation. Mean ice accumulation is probably about 0.02 meters, ranging from the typical .0 to about 0.15 meters depending on winter severity.

Placement of turbines in the lake would likely catalyze ice formation around the tower bases, by providing a calmer surface downwind of the tower and perhaps in some cases by enhancing heat loss to the atmosphere. As a consequence, turbines would likely develop "ice collars" in mid-to-late winter, especially those in colder waters closer to shore. Even with no general ice accumulation, this "ice collar" phenomenon could complicate boat access to the turbines. However, it could also be advantageous in absorbing occasional impacts from moving ice.

D.2.3 Ice Impact Forces

Ice impacts can impose substantial forces on turbine bases, floats, and mooring lines. Freshwater ice tends to be harder than salt water ice. Its hardness is a function of temperature, decreasing as water temperature increases. Thus, as ice formed in the shallows is blown eastward by southwest or west winds, it tends to soften as it is exposed to warmer water as it moves east. The hardness of ice is also a function of ice floe speed. As a floe speeds up, it is effectively softer, crushable to a greater extent on impact. Ice impact loads are a function of ice thickness, speed, and ice temperature.

In Wisconsin's Lake Michigan Waters, ice impacts tend not to be a major or frequent problem. Ice is most likely to move under the influence of south and southwest winds which tend to be warmer winds. When ice moves in these instances, it tends to move into deeper water which is also slightly warmer. Consequently, moving ice in western Lake Michigan is often softening and slowly melting as it moves. Since the ice is typically not thick to start with, generally 0.2 meter or less in the average winter, on average it has limited potential to create substantial impacts. This potential tends to diminish over time. In addition to softening and melting, ice being blown across the lake surface is likely to crack and break into smaller and smaller pieces as wave action develops in response to the winds moving the ice.

According to NOAA Great Lakes Environmental Research Laboratory expert George Leshkevitch, ice tends to move at two percent of the mean wind speed which is generally less than 20 m/s, hence the ice generally moves at less than 0.4 m/s.

Since both the Mid-Lake Plateau and Two Rivers Ridge are more than ten miles from the shallows along the western shore where ice reaching these areas is most likely to form, these areas are typically affected by ice which has been softened, weakened, partially melted, and largely broken into smaller pieces, limiting its impact potential.

A more serious impact risk could be from a larger ice floe broken off from a more ice-bound region further north, that gets circulated by winds and currents down into central Lake Michigan later as a fairly intact and thick ice floe. While unlikely, this kind of impact could be considerably worse than the more typical case. However, it would likely occur when turbine bases would have ice collars, because it would require northerly winds to get the ice moving south, and northerly winds cold enough to preserve thick ice would be cold enough to preserve and expand ice collars at turbine bases. A thick ice collar could help dissipate impact force in ice-crushing deformation rather than turbine base/mooring line damage.

D.3 Wind, Wave, and Water Level Extremes Off-shore

We do not have definitive measurements of extreme wind speeds off-shore. The following are our estimates of 100-year-return values for Lake Michigan:

Highest 1-minute-mean wind speed:	90 mph (40 m/s)
Peak gust:	110 mph (49 m/s)

These would apply to all off-shore sites.

We also do not have definitive information as to extreme wave levels. These are our estimates:

2 miles off-shore maximum wave height:	27 feet
5 miles off-shore maximum wave height:	28 feet
20 miles off-shore maximum wave height:	30 feet
Any location means significant wave height:	21 feet
For all locations, extreme wave period:	7.5 seconds

These extreme wave heights apply to Lakes Michigan and Superior. As to Green Bay, we estimate an extreme wave height of 24 feet north of Sturgeon Bay.

There are no tides on Wisconsin lakes. Seiche waves are probably not very large off-shore, and they probably are not typically associated with strong winds on the Wisconsin side of the lake.

Storm surges can occur, particularly when winds are oriented down the long axis of the lake from the north-northeast, and such surges can coincide with extreme waves from the same direction. We are estimating an extreme storm surge of three feet coincident with maximum wave height.

D.4. TRANSMISSION

D.4.1 Transmission System Capabilities, Limitations and Relative Costs by Voltage

Higher voltage lines carry more power and have lower electrical losses than lower voltage lines. High voltage cables placed underwater require greater voltage insulation which increases their initial cost. Costs for underwater cables can be many times the cost for land-based transmission and underwater costs increase with water depth. The cost also varies greatly depending if the transmission line is laid on the lake bottom, trenched in soft sediment or cut into rock. Cutting into rock could increase the cost but also improve the cable's reliability (see discussion below).

AC submarine cables at 345-kV are used elsewhere (e.g., there are several in the New York City Area). However, in the case of Lake Michigan, lines could approach 100 miles in length.[162] At such length, 345-kV cables require reactive compensation to function efficiently.[163] Above-surface substations (on poles or pylons as in large European wind energy projects) with shunt inductors (which look like transformers) would be required at intervals sufficient to cancel out line charging of the underwater cables. To minimize foundation costs, these would preferably be placed in relatively shallow water.[164] Consequently, there could be a cost advantage to routing the underwater cables across relatively shallow portions of the lake bottom, including such features as the Mid-Lake Plateau east of Milwaukee and Port Washington and the Two Rivers Ridge east of Cleveland (S. Manitowoc Co.). The shunt inductor station locations could become prime sites for future large-scale off-shore wind projects, because it would be relatively inexpensive to hook up off-shore wind projects to the grid at such spots if they were already connected to Wisconsin and Michigan by relatively efficient 345-kV lines.

However, a long cable between Wisconsin and Michigan may also have to contend with a large phase angle difference, likely driving the need for expensive phase shifting transformers and making the line very difficult to operate. If a large phase angle difference were to occur with the line open, large amounts of generation (in the thousands of MW) may need to be redispatched in Wisconsin and Lower Michigan to reduce the phase difference before the cable could be closed in.

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[162] ATC does not recommend underwater 345 kV lines for these distances. Direct current (DC) lines are preferred in these applications.

[163] A 345-kV cable can produce significant charging current due to its capacitance. Without compensation to cancel out this "line charging" production of reactive power, a long line segment of underwater transmission could experience excessive voltages and voltage swings under some circumstances. In addition, a long underwater line would get loaded up with MVars, causing its energy losses to increase and consuming much of the line capacity. Placing shunt inductors on such a line allows the operator like ATC to consume some of the excess MVars, maximize line efficiency, and reduce excess voltage swings. In the case of a 400-kV AC. cable proposed underneath a river in New Zealand, the electrical engineers recommended a spacing of about 20 to 30 km between shunt inductor stations. A 345-kV line would have lower line charging and could have these stations spaced about 34.4 percent further apart in this case, about 17 to 25 miles apart.

[164] It is conceivable that a foundation supporting a shunt inductor substation in 200 feet of water could cost as much as $18 million as compared to perhaps $5 million in 100 feet of water, with costs even higher in depths exceeding 200 feet. Given costs and maintenance considerations, it may not be desirable to traverse the deepest portions of the lake with a 345-kV line which would periodically require a shunt inductor station on the surface.

A DC cable would not have the capacitive or phase angle issues. It would require AC/DC converters at the ends and would have lower efficiency than an AC installation. A DC cable would not require shunt inductor stations on the lake and therefore would not provide on-lake points to connect off-shore generation.

<u>Time to Repair or Maintain:</u> If a generator has only one radial line, loss of that line or removing it from service to maintain terminal equipment, would mandate the generator(s) be taken off line during that time. The time to repair an underwater transmission line is so great, that often, multiple lines (or spare cables) are installed at the time of the initial installation. The higher the voltage line, the greater the amount of generation that would not be available without such a redundant line. Normal terminal maintenance is estimated to take about two days each year.

D.4.2 Interconnection Studies

Below are short county-by-county summaries of the existing transmission system's ability to support off-shore wind projects. ATC performs generation-transmission system studies within the ATC footprint as a sub-contractor to MISO. The following information reflects publicly available information from existing generation interconnection studies along Lake Michigan.

<u>Kenosha and Racine Counties</u>

The most representative study for Kenosha and Racine counties is the study of the previously proposed third phase to the Oak Creek expansion. Phase III of this project was to be the addition of 650 MW of combined cycle generation (i.e. coal-fired, IGCC plant) but the project was withdrawn. This new generation would have required the construction of two new 345-kV lines due to transmission system overloads and plant angular instability. The first 345-kV line would have run from the Oak Creek power plant south of Milwaukee to the Granville substation on the north side of Milwaukee and would have mitigated both transmission overloads and plant angular instability issues. The second line would have added a new 345-kV inter-tie between Wisconsin and Illinois and was primarily needed to resolve area angular instability concerns. While a wind project may not exhibit the same angular instability issues as the cancelled combined cycle plant, relief of thermal overloads would be required and some angular instability issues may be created due to moving power across the transmission system.

<u>Milwaukee County</u>

There are no generator interconnection studies available for the Milwaukee area since no new plants connecting to the transmission system have been proposed for this county. However, this is an urban area and the existing facilities are designed primarily for serving load. Although some substations are closer to Lake Michigan, typical issues in urban areas are limited available rights-of-way and space constrained substations. Many substations in this area are served by underground transmission cables and the existing rights-of-way may involve city streets, which can delay implementation of any required system upgrades. The city of Milwaukee is a large load center, and generation sized to match the load at the interconnection may have a reduced impact on the rest of the transmission system.

Ozaukee County

There is an existing 1,200 MW natural-gas fired plant near the Lake Michigan coast in Ozaukee County. The first phase of this plant was placed in-service in 2005 and the newest phase recently went in service. The transmission studies are available from the Midwest ISO. These studies identified the need for rebuilt transmission lines coming to the power plant and reduced fault clearing times in the event of a fault on the nearby system. This plant's angular stability results suggest additional generating facilities in the area might require additional transmission fixes, although the scope of these fixes is not known and would depend on the specific wind project.

Sheboygan County

There is an existing protection scheme at the Edgewater Power Plant in Sheboygan County to trip generation for the loss of the 345-kV outlets due to thermal overloads of the remaining outlet. Additional generation added to this area would be expected to exacerbate this condition, potentially requiring additional protection schemes or transmission upgrades. Generation sized to match local load may have a reduced impact on the transmission system.

Manitowoc and Kewaunee Counties

Any new generation on the 345-kV transmission system in Manitowoc or Kewaunee Counties may have an impact on the Point Beach and Kewaunee nuclear power plants, which operate with specific requirements. Publicly available information from the Midwest ISO on a potential upgrade of the Point Beach power plant indicates that the angular stability of the area generation is affected by additional generation in the area, requiring fixes to the transmission system. Additional generation added in the area, even if the generation does not consist of synchronous machines, may drive additional transmission fixes. In addition, publicly available information on proposed wind energy project interconnections to the 138-kV system near the Kewaunee nuclear power plant identified the potential for dynamic voltage support, a possible indicator of a weak system.

Door County

No generator interconnection studies have been performed in Door County since no new plants connecting to the transmission system have been proposed for this county. However, the transmission facilities in this area are primarily designed for serving load. ATC's Ten Year Assessment includes a proposed 138-kV line for this area, and generation sized to match the local load may have a reduced impact on the transmission system.

Douglas County

The only ATC transmission facilities in Douglas County are a single 345-kV line connecting Duluth, Minnesota and Minong, Wisconsin. No generator interconnection studies have been performed for this transmission line and any possible impacts are unknown.

Bayfield County

No interconnection requests have been received in Bayfield County and, consequently, no generator interconnection studies have been performed. Bayfield County is a very rural area with low load growth and low population density. As such, its transmission resources are small and generally have not been designed for generation interconnections.

Ashland County

No recent generator interconnection studies have been performed for Ashland County. NSPW does own a generation facility near Lake Superior and adequate transmission facilities exist to provide outlet for approximately 67 MW of generation already in service.

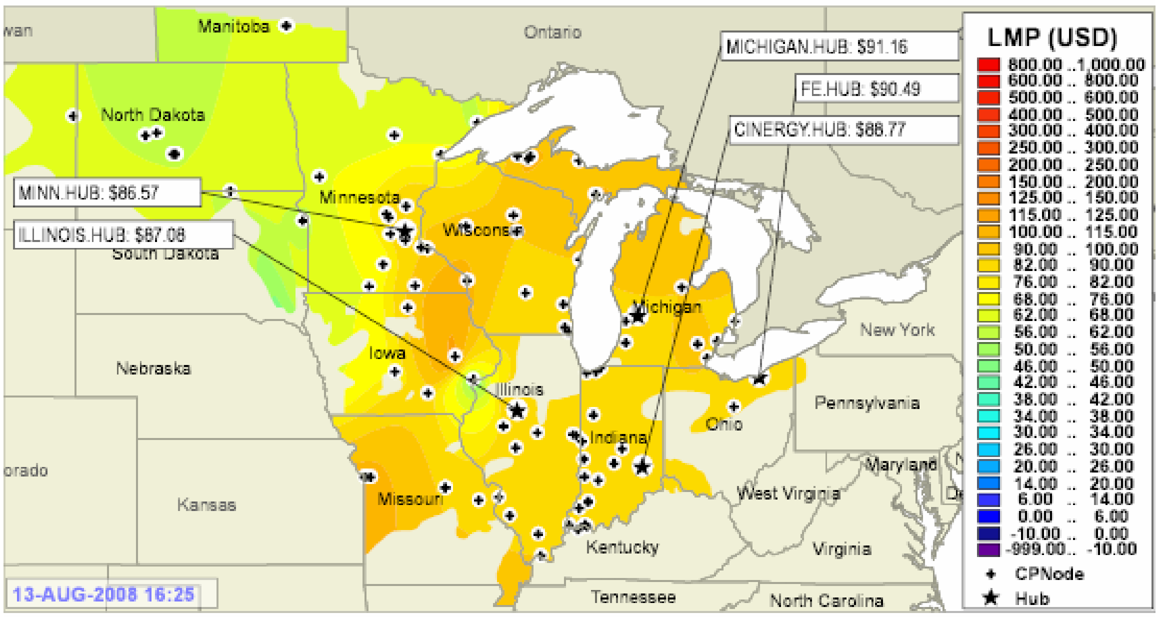
Iron County

No recent generator interconnection studies have been performed for interconnection requests in Iron County. There is an existing hydroelectric generation facility at Saxon Falls capable of producing approximately 25 MW of power and sufficient transmission exists to serve that load. In addition, the town of Hurley is located in Iron County. Across the border in Gogebic County (Michigan), the town of Ironwood is also served by transmission passing through Iron County.

D.5 WISCONSIN V. GREAT PLAINS WIND ENERGY

Electric energy in Wisconsin is bought and sold in a 14-state regional market (see map below) on a day-ahead and real-time basis. The generation in the entire region is dispatched centrally by the Midwest Independent System Operator (MISO). The generation is dispatched to meet demand for electricity (loads) throughout the day every five minutes. MISO's objective is to use the most cost-effective generation available across its entire region to meet the next increment of electricity demand. Sometimes the most inexpensive generation cannot be used because there are transmission limitations on the system. The costs that are created by this lack of transmission are congestion costs and increased loss costs. Congestion costs are created by more megawatts wanting to flow over the transmission line than the capacity of the line will allow. Loss costs are created by the physical loss of kWh that occurs when electricity flows over transmission or distribution lines. Moving power longer distances creates greater losses on the system, increasing loss costs. It can also increase congestion costs as large blocks of power try to flow over lines that do not have sufficient capacity. The combination of the three costs described above, the cost of the next most cost-effective generation, the loss costs and the congestion costs, is described as the locational marginal price (LMP). It is so named because it is highly dependent on the location of where the power is available and where it is needed.

Figure D-1: MISO LMP Map



Source: MISO

Congestion costs and losses resulting from the use of northern Great Plains wind to meet Wisconsin RPS requirements could have a significant effect on the costs of compliance. The costs associated with congestion and losses are reflected in the LMP as described above. Typically in the MISO market, LMPs in the west have been lower than prices in Wisconsin. Given the excellent on-shore wind regime in the west, many wind projects are being proposed for western Minnesota and South Dakota. The wind resource, however, is very far from where electricity is demanded and the transmission system is currently not robust enough to support delivering all the wind power to the loads. The task of forecasting LMPs require the use of models that rely on very complex data inputs as well as assumptions about where generation plants and transmission lines are located. The number of interconnection requests for wind projects in the northern Great Plains and the difficulty in bringing transmission projects to fruition make it reasonable to expect that future LMPs in that region are likely to be systemically lower than mean market-wide prices and lower than LMPs in Wisconsin. This difference in LMPs is the combined effect of congestion and losses and will be a key component in understanding the magnitude of the friction cost associated with acquiring these distant wind resources to serve Wisconsin load.

Furthermore, the MISO currently allows requests for project interconnections that would supply only energy and no capacity and many wind projects have made such requests. The expectation is that such interconnections will require fewer transmission upgrades than those required for network interconnections. This would mean commensurately less energy transfer capability from the transmission lines and more congestion when those turbines were operating. When the wind turbines are operating at full output, they will absorb more of the available transmission system and serve more of the load, sometimes causing a need to back down conventional generation. If this happens during the evening and nighttime hours, baseload coal generation may need to be backed down. The result could be a further increase in congestion and loss costs for Wisconsin consumers.

Another key cost component associated with using northern Great Plains wind to serve Wisconsin load is the capital cost of transmission upgrades that are needed to accommodate Wisconsin load serving entities' requests for interconnection of the wind projects. Below is a simplistic comparison of the cost of western Minnesota on-shore wind versus Wisconsin on-shore wind. Only two variables are taken into account - very rough transmission costs and the difference in capacity factors of the wind turbines due to the better wind regime in western Minnesota. The calculations show a 4:1 advantage from a transmission capital cost perspective for building wind in Wisconsin rather than building it in Minnesota and building the transmission needed to move it to Wisconsin.

Please note that this is a very simplistic calculation for illustrative purposes only. These are two examples of how transmission interconnections for wind projects could unfold. It is possible that out-of-state wind projects would be built closer to Wisconsin, close to existing transmission lines or close to load, all of which would reduce the costs significantly. Also, as outlined above, calculating the cost of moving electricity in a regional market such as MISO is an incredibly complex task involving thousands of assumptions about generation, load and transmission capabilities on the system. Actual studies of the cost of interconnecting wind often take months of analysis and design to get good cost estimates. In addition, once the transmission line is built, it is impossible to say "which" electrons it is transporting. It becomes part of a huge interconnected "machine" which stretches from the Midwest to the east coast and is governed by the laws of physics rather than economics.

Table D-3: Calculation of the Cost Differential for Out-of-State Versus In-State Wind

	Out-of-State Western Minnesota	**In-State Wisconsin**
MWs	500	500
Capacity Factor	0.45	0.30
Hours in Year	8,760	8,760
Transmission Cost Estimate	600,000,000	90,000,000
MWhs Produced	78,840,000	52,560,000
Transmission Cost/MWh	$7.61	$1.71

Assumptions:

1. In-State Transmission Costs = average of currently estimated ATC costs for wind generation interconnection ($180,000/MW).

2. Out-of-State Transmission Costs: assumes a 300-mile 345 kV line at $2 million/mile with no lower voltage upgrades or actual interconnections. These costs represent the transmission costs of a wind project that was distant from loads and from existing transmission.

3. Used 40-year life of transmission line to estimate MWhs produced.

The table above shows a comparison between an in-state wind project and an out-of-state wind project that would need significant transmission improvements to move the power to load.

There may be out-of-state wind projects that are closer to Wisconsin, close to existing transmission or close to load centers that could absorb the power. These projects could provide a higher capacity factor from western winds with lower expenditures for any necessary transmission upgrades and the cost differential between in-state and out-of-state would be lower as a result.

One other issue to consider regarding regional transmission is the uncertainty of how costs for transmission upgrades will be allocated. There's currently discussion about the merits of a 765 kV system upgrade to move wind power from the northern Great Plains to Lake Michigan and east coast load centers. The cost for such a system is tens of billions of dollars and it is possible that Wisconsin electricity consumers would be expected to pay for some of it. If Wisconsin pursues off-shore wind there will be costs to upgrade the in-state transmission system and those costs will likely be solely born by ATC customers. The only exception to this is if Wisconsin were to decide to do a larger scale 345 kV build-out to support wind development that also provided reliability benefits for the MISO region. In that scenario, twenty percent of the cost would be shared MISO-wide on a postage stamp basis and the remaining 80 percent would be cost-shared with some entities in MISO depending on the benefits they receive.

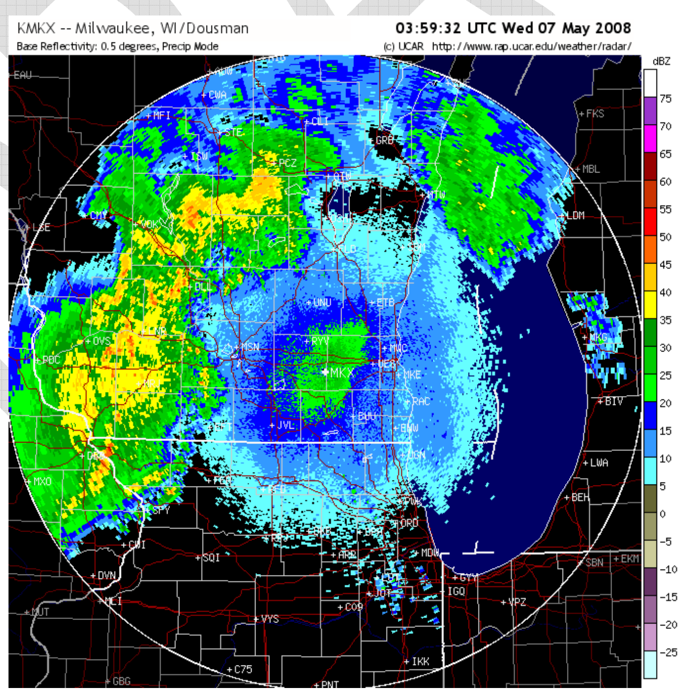
APPENDIX E - BIRD MIGRATION AND NEXRAD WEATHER RADAR[165]

Today with the combination of the Internet and the US Government NOAA-operated Nexrad weather radar network it is possible to observe radar detection images of swarms of millions of migrating birds in real time.

Nexrad radar provides a direct, quantifiable, color-based imagery method to determine the timing and intensity of migration, density of birds on nights during migration, and their direction of flight. Occasional isolated flocks of diurnal migrants are also detected. It does not allow identification of bird species or groups, indicate which species are flying at particular heights, or distinguish birds from bats.

During peak migration in May and September density can be as high as 1,500 or more birds per cubic kilometer. Using average speeds of migrants one can estimate that more than three million birds cross the southern border of Wisconsin per hour on a typical May night of migration and as high as thirty million cross during the three or four heaviest nights.

The nightly effects of weather and migration can be observed by even untrained radar observers. The image below shows the differences between weather (the more ragged showers toward the left of the image) and migrating birds (the "donut" in the center of the image). Note the heavy May swarm with many birds over the Lake as showers approach from the Northwest. The detection colors indicate at least 300 birds per cubic kilometer over the Lake.



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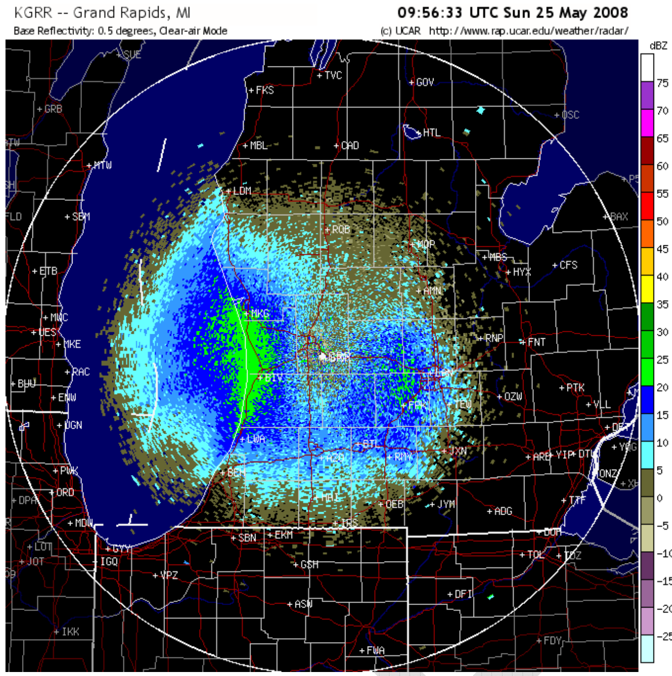
[165] Information in this Appendix is adapted from http://my.execpc.com/CE/5F/idzikoj/nexrad/nexweb/nex.htm. For more information, contact John Idzikowski (414-229-6274, idzikoj@uwm.edu).

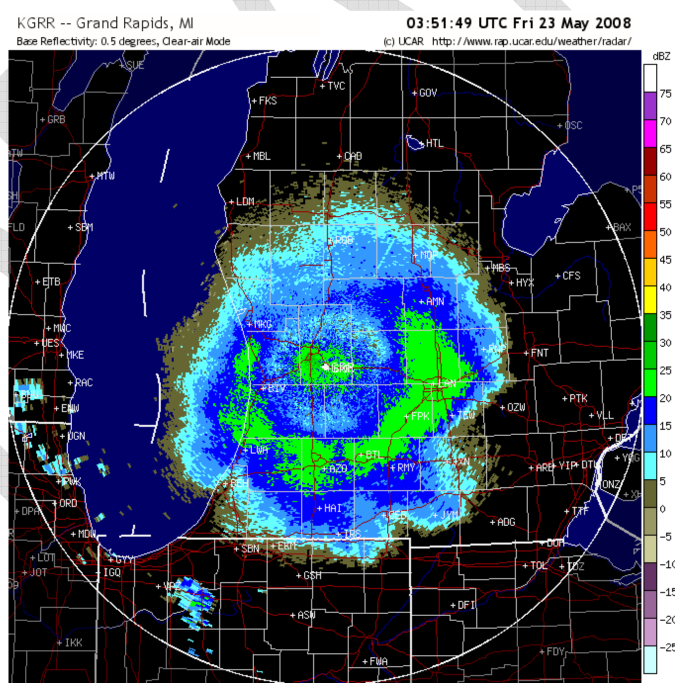
We are beginning to understand how nocturnal migrants may be negotiating the potential hazards presented by the size of the Great Lakes. The following web page shows an animated image of bird migration through one night in May over southeast Wisconsin and Lake Michigan: http://my.execpc.com/CE/5F/idzikoj/nexrad/nexweb/angif.htm

The following graphic shows birds flying over southern Wisconsin and adjacent Lake Michigan and helps explain their behavior at exodus (take off) and dawn, when they need to make landfall:

The image below shows birds over the Lake in numbers of 500 birds per cubic kilometer out as far as 20 miles:



In the next image, note the heavy swarm over Lake Michigan heading to land and especially the concentration of migrants landing near the Michigan shoreline:



Radar data also demonstrates that nocturnal migration is affected by low ceilings, and has a somewhat predictable level of occurrence. Some species that migrate at night may use the airspace well below 600 feet in these low ceiling conditions which could be within the zone of turbine blades. There is also much variation in migration from night to night.

SUMMARY

While Nexrad provides gross information about nocturnal bird migration in the western Great Lakes, and it clearly shows that there can be millions of migrants over the open water of Lake Michigan at dawn, it cannot show us how birds use the space. This is especially true of the near-shore area that they must traverse to make landfall once they make predawn decisions of flight direction. It will only be through micro-radar studies using portable radar units positioned at the shoreline under many different weather conditions that we can learn how this space is used.

APPENDIX F - IMPORTANT BIRD AREAS AND STOPOVER LOCATIONS

Migratory Bird Stopover Sites

The Great Lakes region - particularly the shoreline area - plays a crucial role for millions of migrating birds, including raptors, land birds, and waterfowl. The region is part of a global network of sites that links breeding grounds as far north as Greenland and the Arctic Ocean to wintering grounds as far south as Argentina's Tierra del Fuego. These stopover sites - all of the sites migratory birds use in the course of their spring and fall migrations - are recognized as important conservation priorities by many national and international conservation organizations and agencies, such as the American Bird Conservancy, Bird Studies Canada, Ducks Unlimited, National Audubon Society, the Wildlife Habitat Council, the Upper Mississippi River-Great Lakes Joint Venture,[166] and the U.S. Fish and Wildlife Service.

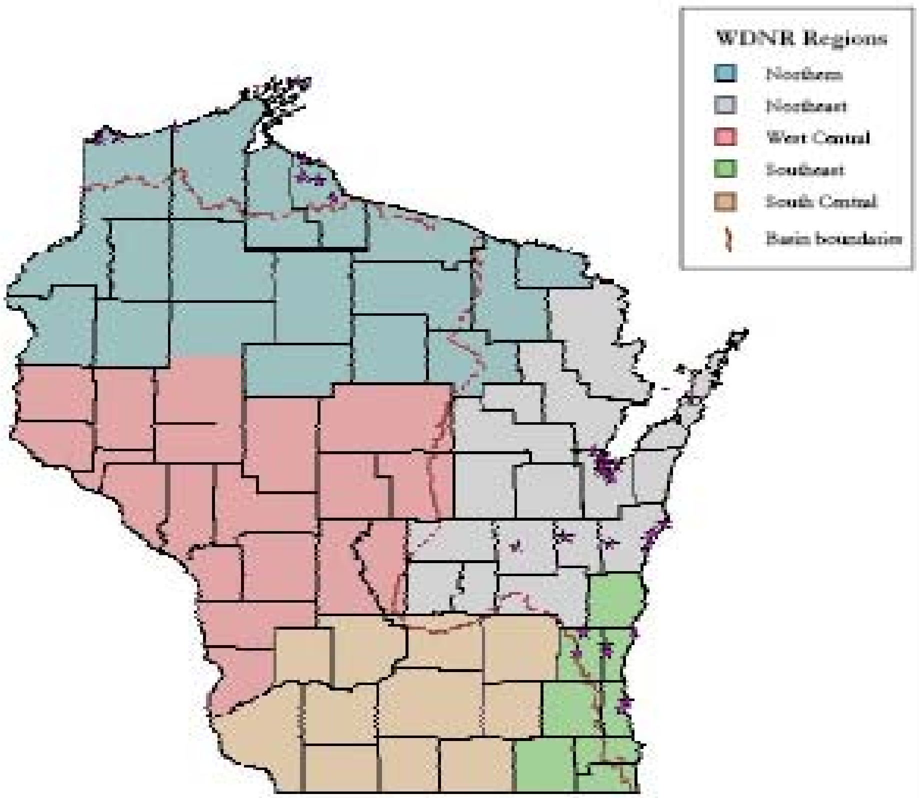
In a series of workshops held in 2006, regional experts identified many sites in the western Great Lakes as important bird stopover sites, many of which are identified on the map and table below. These were the first, most obvious, near-shore sites to be identified and do not constitute all sites on the Great Lakes which may be important for birds.

To compensate for the gaps in knowledge of these sites, GIS models of stopover site attributes were developed. Based on habitat features identified from the literature and from expert opinion, the models predict where in the Great Lakes basins of Wisconsin birds are most likely to congregate during the migratory seasons.

For more detailed information about stopover sites in general and these sites and models in particular, contact Kim Grveles, WDNR (608-266-0822; kim.grveles@wisconsin.gov) or Sumner Matteson, WDNR (608-266-0822; sumner.matteson@wisconsin.gov).

[166] The mission of the Upper Mississippi River and Great Lakes Region Joint Venture (UMGL JV) is to deliver the full spectrum of bird conservation through regionally based, biologically driven, landscape-oriented partnerships. The JV currently serves as the "all bird" conservation coordinating body of the region and delivers conservation strategies and tools to implementation partners for all bird species. The geographic boundary of the UMGL JV includes all of Illinois, Indiana, Michigan, Ohio and Wisconsin, plus portions of Minnesota, Iowa, Missouri, Kansas and Nebraska.

**Protecting Migratory Bird Stopover Sites
in the Western Great Lakes Basin
Important Sites from Workshops*
DRAFT**



* This preliminary map does not show all priority sites. Experts attending workshops in 2006 estimated bird-use per season to be 10,000 or more birds for one or more bird groups at each site shown. Please refer to accompanying site table for details.

List Of Important Bird Areas Along The Shores Of Lakes Michigan And Superior

This list represents important bird areas (IBAs) along the lakeshore that were identified during the first round of IBA nominations in Wisconsin from 2003 to 2007. It is not an exhaustive list of all sites that potentially could qualify as IBAs; additional sites may be identified in subsequent rounds of nominations.

More detailed information on each of these sites, including bird data, site descriptions, importance to birds, and conservation overviews, can be found in the following publication:

> Steele, Y. (editor). 2007. Important Bird Areas of Wisconsin: Critical Sites for the Conservation and Management of Wisconsin's Birds. Wisconsin Department of Natural Resources, PUB-WM-475-2007, Madison, WI.

General information about the IBA Program, including a program overview and frequently-asked questions, can be found at: http://www.wisconsinbirds.org/iba

Lake Michigan Shoreline IBAs
Ozaukee Bight Lakeshore Migration Corridor - Ozaukee County
Harrington Beach Lakeshore Migration Corridor - Ozaukee County
Cleveland Lakeshore Migration Corridor – Manitowoc and Sheboygan counties
Woodland Dunes Nature Preserve - Manitowoc County
Point Beach State Forest - Manitowoc County
Whitefish Dunes/Shivering Sands - Door County
Toft Point/Ridges Sanctuary/Mud Lake - Door County
Mink River Estuary/Newport State Park - Door County
Lower Green Bay Islands/Bay Beach Wildlife Sanctuary - Brown County
Green Bay West Shore Wetlands - Brown, Oconto, and Marinette counties
Lower Peshtigo River - Marinette County
Seagull Bar - Marinette County

Lake Superior Shoreline IBAs
Kakagon/Bad River Wetlands & Forest Corridor - Ashland County
Lower Chequamegon Bay – Ashland and Bayfield counties
Apostle Islands National Lakeshore – Ashland and Bayfield counties
South Shore Wetlands - Bayfield County
Wisconsin Point - Douglas County

APPENDIX G - WIND POWER DEVELOPMENT IN WISCONSIN
1998 – 2008

Table G-1: Wisconsin Terrestrial Wind Projects as of 2008

County	Owner/Project Title	Start Date	MW
Dodge	Babcock & Brown Butler Ridge Wind Farm	December 2008 (est.)	54
Fond du Lac	Wisconsin Power & Light Cedar Ridge Wind farm	December 2008 (est.)	68
Fond du Lac/Dodge	Invenergy, LLC Forward Energy Center	May 2008	129
Fond du Lac	We-Energies Blue Sky Green Field	May 2008	145
Iowa	FPL Energy Montfort	July 2001	30
Kewaunee	Madison Gas & Electric Rosiere	June 1999	11.2
Kewaunee	Wisconsin Public Service Corp. Lincoln	June 1999	9.2
Fond du Lac	We-Energies Byron	June 1999	1.3
Brown	Wisconsin Public Service Corp. Glenmore	Feb. 1998	1.2

Source: RENEW Wisconsin

APPENDIX H - ADDITIONAL INFORMATION ON CURRENT AND PLANNED OFF-SHORE WIND PROJECTS

Table H-1: European Off-shore Wind Energy Project – In-Service

Year Online	Country	Project	Capacity (MW)	Number of Turbines	Water Depth (m)	Distance to Shore (km)
1991	Denmark	Vindeby	4.95	11	2.5-5	2.5
1995	Denmark	Tunø Knob	5	10	0.8-4	6
1998	Sweden	Bockstigen	2.8	5	6-8	3
2000	United Kingdom	Blyth Off-shore	3.8	2	6	1
2001	Denmark	Middelgrunden	40	20	5-10	2-3
2001	Sweden	Utgrunden I	10.5	7	4-10	7
2002	Denmark	Horns Rev	160	80	6-14	14-20
2002	Sweden	Yttre Stengrund	10	5	8-12	4
2003	Denmark	Frederikshavn	10.6		3	0.8
2003	United Kingdom	North Hoyle	60	30	5-12	7.5
2003	Denmark	Nysted Havmøllepark	165.6	72	6-9	6
2003	Denmark	Rønland	17.2	8	3	Near Shore
2003	Denmark	Samsø	23	4	11-18	3.5
2004	Ireland	Arklow Bank	25.2	7	15	7
2004	United Kingdom	Scroby Sands	60	30	2-10	3
2005	United Kingdom	Kentish Flats	90	30	5	8.5
2006	United Kingdom	Barrow	90	30	>15	7
2006	Netherlands	Off-Shore Wind energy project Egmond aan Zee (OWEZ)	108	36	17-23	8-12
2007	United Kingdom	Beatrice	10	2	>40	Unknown
2007	United Kingdom	Burbo Bank	90	25	10	5.2
2007	Sweden	Lillgrund	110	48	2.5-9	10
2008	Netherlands	Off-Shore Wind Q7	120	60	19-24	>23

Source: European Wind Energy Association (EWEA)

APPENDIX H (Continued) - ADDITIONAL INFORMATION ON CURRENT AND PLANNED OFF-SHORE WIND PROJECTS

Table H-2: European Off-Shore Wind Energy Projects – Under Construction

Year Online	Country	Project	Capacity (MW)	Number of Turbines	Water Depth (m)	Distance to Shore (km)
2009	Sweden	Gässlingegrund	30	10	4-10	4
2009	Denmark	Horns Rev II	200	10-18	NC	17
2010	Denmark	Nysted Havmøllepark II	200	6-9	NC	10
*NR	United Kingdom	Inner Dowsing	90	27	10	5.2
*NR	United Kingdom	Lynn	97	30		5.2
*NR	United Kingdom	Ryhl Flats	90	25	8	8
*NR	United Kingdom	Solway Firth/Robin Rigg A	90	30	>5	9.5
*NR	United Kingdom	Solway Firth/Robin Rigg B	90	30	>5	9.5

***Not Reported**

Source: EWEA

Table H-3: Proposed Off-Shore Projects in the U.S.

Project Name/ Developer	Location	Number of Turbines	Status
Cape Wind	Nantucket Sound	130 turbines	Moving through MMS process
FPL Energy	Long Island Sound	40 turbines	Project on hold
W.E.S.T.	Galveston, TX	50 to 60 turbines	Signed lease with General Land Office
Bluewater Wind	Delaware	200 turbines	Awaiting state approval of contract
Hull Municipal	Boston Harbor	4 turbines	Site data collection underway
Patriot Renewables	Buzzards Bay, MA	90 to 120 turbines	Site studies underway
Southern Company	Georgia coast	3 to 5 turbines	Feasibility being studied
Great Lakes Wind Energy Center	Lake Erie	Up to 20 MW	Feasibility being studied

Source: American Wind Energy Association (AWEA)